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1915.

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THE ASSOCIATION was organized in Boston, Mass., on June 21, 1882, with the object of providing its members with means of social intercourse and for the exchange of knowledge pertaining to the construction and management of water works. From an original membership of only TWENTY-SEVEN, its growth has prospered until now it includes the names of over **800** men. Its membership is divided into two principal classes, viz.: MEMBERS and ASSOCIATES. Members are divided into two classes, viz.: RESIDENT and NON-RESIDENT, — the former comprising those residing within the limits of New England, while the latter class includes those residing elsewhere. The INITIATION fee for the former class is FIVE dollars; for the latter, THREE dollars. The annual dues for both classes of Active membership are THREE dollars. Associate membership is open to firms or agents of firms engaged in dealing in water works supplies. The initiation fee for Associate membership is TEN dollars, and the annual dues FIFTEEN dollars. This Association has six regular meetings each year, all of which, except the annual convention in September, are held at Boston.

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LEONARD METCALF,

President New England Water Works Association,

1915.

RATES FOR WATER SUPPLY

BY B. M. WAGNER

This paper was read by title only. Discussion is invited for publication in subsequent issues of the Journal.

New England Water Works Association.

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This Association, as a body, is not responsible for the statements or opinions of any of its members.

RATES FOR WATER SUPPLY.

BY B. M. WAGNER, C.E.

[*Read November 11, 1914.*]

The writer was given an assignment by his official superior, some time ago, to prepare a digest of what had been done in the matter of fixing water rates, and considered that while the matter he herewith submits presents no new or startling feature, it might be of interest to our members as a review of the subject of water rates, and perhaps bring about a discussion that would clear up some points that seem in dispute at the present time.

So far as can be ascertained, the earliest rates were a matter of guess work, pure and simple, and as new water works were brought into existence their rates were based either on an average of the rates in use, at the time, in other communities, or were, in some cases, made equal to the lowest existing water rates then in use. In general, no attention was paid to cost of service.

Flat Rates.

All of the earlier rates were flat rates, that is, a fixed price per year covered a certain class of service without any regard to the quantity of water used. The details of such flat rates varied somewhat, but they can be divided broadly into the following classes:

(*a*) The main rate is based on frontage of the building along the street or service main, said rate including some fixtures, with certain additional charges for all excess fixtures. New York and

Chicago rates are based on such a system and examples of the rate charged are shown on Table 1.

This is positively the most unscientific method of charging for water, and has no reason for being, except custom.

(*b*) The main rate is based on the number of rooms in the house to be served, in general with a minimum rate covering from one to a fixed number of rooms, and with additional charges covering the use of all fixtures except the kitchen sink. Table 2 gives extracts from the rates of this kind used in St. Louis.

This method is in use in the greater part of the United States, and while not as poor a method as the frontage rate method, has very little to commend it and is, in any case, an inducement to waste water. Table 3 gives average from a compilation made by Mr. D. R. Gwinn, in 1908, of rates used in 375 cities in the United States, and averages given by F. J. Jordan in 1909.

TABLE 1.

EXAMPLES OF FLAT FRONTAGE AND FIXTURE RATES.

NEW YORK CITY — One Family.			
Front Width.	1-Story.	3-Story.	5-Story.
16 ft. or less	$4.00	$6.00	$8.00
16 ft. to 18 ft.	5.00	7.00	9.00
18 ft. to 20 ft.	6.00	8.00	10.00
20 ft. to 22½ ft.	7.00	9.00	11.00
22½ ft. to 25 ft.	8.00	10.00	12.00
	Etc.		
37½ ft. to 50 ft.	14.00	16.00	18.00

CHICAGO — One Family.			
Front Width.	1-Story.	3-Story.	5-Story.
12 ft. or less	$2.50	$5.50	$8.50
12 ft. to 15 ft.	3.50	6.50	9.50
15 ft. to 18 ft.	4.50	7.50	10.50
18 ft. to 21 ft.	6.00	9.00	12.00
21 ft. to 24 ft.	7.00	10.00	13.00
	Etc.		
82 ft. to 87 ft.	20.00	23.00	26.00

Other widths and number of stories in proportion.

New York.	Chicago.
Includes 1 Water closet.	Includes water closets.
1 Bath.	Baths.
Kitchen sink.	Kitchen sinks.
Wash tubs.	Wash tubs.
Wash basins.	Wash basins.
Family not defined.	Family limited to 12 persons.
Additional baths, $3.00.	Over 12 persons, $0.50 per person.
Additional water closets, $2.00.	Additional families, $7.00 per full set fixtures.
Hose only on meter.	Hose, 30 ft. front or less, $2.00.
Additional families, $1.00 plus fixture charges.	Hose, 30 ft. front to 50 ft., $3.00.
	Steam heating, $0.05 per ton coal used.

Building Purposes.

New York.		Chicago.
$0.10	Per 1 000 brick.	$0.05
.05	Per cu. yd. masonry.	—
—	Per cord stone.	.06
—	Per cu. yd. concrete.	.02
.40	Per 100 sq. yd. plaster.	.15

Samples of Miscellaneous Rates per Year in Addition to Flat Rates.

New York.		Chicago.
$5.00	Barber shop, 3 chairs.	—
1.00	Barber shop, additional chair.	—
—	Barber shop, bath tub.	$6.00
3.00	Bakery, per oven.	—
—	Bakery, per barrel flour.	.01
—	Wash basins.	2.50
2.00	Water closet.	3.50
—	Urinal.	1.50
—	Laundry tubs.	1.75
5.00 up	Dining saloons.	1.00 per table.
5.00	Retail fish stands.	1.50
1.00	Stables, per stall.	1.00 to 2.00.
—	Stables, hose.	3.00
8.00 up	Laundries.	—
10.00 up	Liquor saloons.	2.00 per bar, 2 faucets.
—	Liquor saloons, additional faucets.	1.00
—	Liquor saloons, hydraulic pump.	3.00
5.00	Photo galleries.	10.00
5.00 up	Soda fountains.	3.00 up.

New York.		Chicago.
10.00 per h.p.	Steam boilers up to 10 h.p.	4.00 per 10-hr. day.
7.50 per h.p. over 10 h.p.	Steam boilers 10 to 15 h.p.	4.00 per 10-hr. day.
5.00 per h.p. over 15 h.p.	Steam boilers 15 h.p. up.	4.00 per 10-hr. day.
5.00 to 10.00	Florists.	—
7.50	Milk depots.	3.00 up to 16-gal. limit.
10.00	Bottling establishment.	10.00

Meters.

In New York the Commissioner has the right to order a meter placed in any place where water is furnished for business consumption. Expense of meter and setting of same is on the consumer. Meter rate, 10 cents per 100 cu. ft.

In Chicago every building where the net assessment under frontage and fixture rates equals $100 or more per annum must be metered. City supplies and sets meters at its own expense. Meter rates, 62½ cents per 1 000 cu. ft., less 10 cents per 1 000 deduction if the bill is paid within 30 days.

TABLE 2.

FLAT RATE ON ROOM BASIS, ST. LOUIS, MO.

1 to 3 rooms	$2.00 per year.	Includes kitchen sink only.
4 to 5 rooms	3.00 per year.	
Each additional room	1.00 per room per year.	
Tenement rooms	1.00 per year each.	
Private baths	2.00 per year each.	
Private water closets	3.00 per year each.	
Beds, lodging house	.50 per year each.	
Public baths	15.00 per year each.	
Public water closets	10.00 per year each.	
Public urinal	20.00 per year each.	
Churches	10.00 per year each.	
Club rooms	20.00 per year each.	
Schools	.05 per scholar.	
Halls	5.00 per year.	
Horses and mules	3.00 per year each.	
Cows	1.00 per year each.	
Vehicles	2.00 per year each.	
Stable, hose	5.00 per year.	
Livery, hose	50.00 per year.	
Dairy, hose	20.00 per year.	
Stables, per stall	2.00 per year.	

Stores	10.00 per year.
Shops and offices	5.00 per year.
Barber shop, one chair	5.00 per year.
Barber shop, two chairs	7.00 per year.
Barber shop, three chairs	9.00 per year, etc.
Candy and ice-cream saloon	15.00 per year.
Restaurants	20.00 per year.
Saloons	20.00 per year.
Lunch rooms	15.00 per year.
Photo galleries	20.00 per year.
Washing bottles	25.00 per year.
Bakeries	10.00 per year.
Laundries	20.00 per year.
Soda-water fountains	50.00 per year.

Meter rates and regulations not available.

The fixture and business rates are in addition to regular flat rates based on rooms.

TABLE 3.

AVERAGE WATER RATES COMPILED BY D. R. GWYNN IN 1908 — 375 CITIES, UNITED STATES.

	Per Annum.
6-room house (includes only kitchen sink)	$6.40
Bath tub	3.40
Water closet	3.38
Wash basin	1.74
Hose (lot, 50 x 140)	5.20
Total	$20.12
Meter rate, maximum per 1 000 gal	$0.262
Meter rate, minimum per 1 000 gal	.092

ANOTHER AVERAGE GIVEN FOR UNITED STATES. F. J. JORDAN. (1909.)

	Per Annum.
6-room house (water in kitchen only)	$6.28
Bath, water closet, basin and wash tubs	7.21
Hose for 40-ft. frontage	4.94
Total	$18.43
Meter rate, maximum per 1 000 gal	$0.22
Meter rate, minimum per 1 000 gal	.09

HYDRANT RENTALS. F. J. JORDAN. (1909.)

	Per Annum.
Average for United States	$47.00
Minimum for United States	8.00
Maximum for United States	79.00

HYDRANT RENTALS. MR. SAWYER. (1903.)

	Per Annum.
Average for United States	$49.43

HYDRANT RENTALS. METCALF, KUICHLING, AND HAWLEY. (1911.)

	Per Year.
Average, 22 cities (Eastern states)	$29.38
Average, 73 cities (Central and S. W. states)	45.03
Average, 24 cities (Southern states)	42.54
Average, 6 cities (Western states)	28.42
Average, 125 cities	$41.05

(*c*) A flat minimum rate, based on the size of tap supplying the premises, with charges covering all fixtures.

This method is used in Philadelphia, and extracts from the Philadelphia rates are given in Table 4. This seems a more logical method, although many causes exist that would prevent it from being a just and equitable tax in every instance.

TABLE 4.

FLAT RATES ON FIXTURE BASIS.

Philadelphia provides a charge for each fixture with a minimum charge per each size tap. Fixtures are charged for as follows:

	Each.
Kitchen sink	$5.00
Bath tubs	3.00
Basins, slop sinks	1.00
Water closets, siphon flush	5.00
Urinal siphon flush	5.00
Wash tubs (2 tubs)	1.00
Hose privilege	5.00
Dwellinghouses without hydrant or sink on premises,	$5.00
Building, 1 000 brick	.05
Building, perch stone	.02

Samples of Additions to Dwelling Charges for Business Purposes.

	Per Year.
Bakeries	$3.00
Barber shops	3.00
Bars	20.00
Baths	6.00
Photographers, per operator	5.00
Boilers, per h.p.	2.00
Milk houses	5.00
Heating boilers	5.00
Fish stalls, each	5.00

Minimum Rates per Tap.

½ in.	$5.00
⅝ in.	16.00
¾ in.	26.00
1 in.	40.00
1¼ in.	62.50
1½ in.	90.00
2 in.	160.00
3 in.	360.00
4 in.	640.00
6 in.	1 440.00

Minimum Meter Rates.

⅝ in.	$8.00
½ in.	5.00
¾ in.	13.00
1 in.	20.00
1¼ in.	31.25
1½ in.	45.00
2 in.	80.00
3 in.	180.00
4 in.	320.00
6 in.	720.00

Meter charge, 30 cents per 1 000 cu. ft.

Meters are property of city. No rental charged. Consumers liable for damages exclusive of wear and tear, or fire. Director of Public Works has power to meter any place where city water is used. Charitable institutions pay 4½ cents per 1 000 cu. ft. of water used.

(*d*) A flat rate method that is not in use but has certain advantages over those previously mentioned would be along the lines of a rate proportional to floor space supplied.

Mr. W. W. Brush, Deputy Chief Engineer of Water Supply, New York City, made certain investigations in various classes of buildings throughout that city and found a remarkable uniformity of water consumption based on floor area, and if a flat rate is used it would seem a more equitable proposition to charge for water based on actual floor areas supplied rather than on a frontage alone.

In all places where flat rates are in use provision is made either for optional or compulsory metering of the water used by certain classes of consumers.

Meter Rates.

The tendency of the present day is more and more towards metering of all services, and is based on the logical idea that each consumer should be obliged to pay only for the water actually used or for service rendered, irrespective of whether the saving in consumption of water is or is not sufficient to justify the expenditure for meter service.

However, the mere fact that all services are metered does not guarantee a fair deal to all consumers, as in some cases the meter rates are nearly as inequitable as the flat rates would be.

At present the following classes of meter rates are in use:

(*a*) The fixed rate; that is, a fixed price per 100 cu. ft., or per 1 000 gal., with no limit as to amount of water used or not used.

This method is generally in use where the consumer pays for the furnishing and installing of the meter. In this connection it may be of interest to know that in Wisconsin the Railroad Commission in 1909 gave a decision that a city has no right to compel a consumer to either rent or purchase a meter, much less a meter of any particular make or type. At San Diego, Cal., on the other hand, the consumer pays the city a fixed sum for the installation of each size of meter and service. This payment not only covers cost of installation, but also perpetual maintenance.

The trouble with a fixed rate is, that unless it is unduly high the water works are not apt to be on a paying basis. Take, for instance, a flat rate of 10 cents per 1 000 gal. The water used by an ordinary family of five persons would be about 3 000 gal. per month, or, at the above rate, $3.60 per year, which would hardly

be a paying proposition for a water works. To avoid this contingency a minimum charge is sometimes provided for, covering all water used up to a certain fixed amount.

(*b*) A sliding scale where the small consumer pays the maximum rate and the price is graded inversely to the amount of water used.

While not an equitable arrangement, this form of rate has been extensively used, and is defended by its advocates on the grounds of general business practice as between retail and wholesale consumers. In this system of rates, as in (*a*), the consumer either owns and pays for the meter, or the cost of same must be covered by the rates charged. The weak point of this form of rates may be illustrated by the experience of Springfield, Mass., in 1910. Meter rates ranged from a maximum of 25 cents per 1 000 gal. for small consumers, to a minimum of 6 cents for the largest consumers, while the actual cost of furnishing the water was $9\frac{1}{2}$ cents per 1 000 gal.

(*c*) A fixed charge per annum for each size of service, covering readiness to serve with a certain amount of water included, and a fixed or sliding rate per 1 000 gal. consumed over and above the amounts allowed in the fixed charge.

(*d*) A fixed charge per annum for each size of service that covers, simply, "readiness to serve," all water used being paid for at a fixed rate per 1 000 gal. or per 100 cu. ft.

This last is the form of rate that is considered by most experts and the various commissions as being the logical, equitable, and scientific form of rate.

In the form of rates considered under (*c*) and (*d*) the fixed charge is taken as covering certain fixed expenses and charges that exist whether water is used or not, the difference being that in the form considered under (*c*) the fixed charge is made large enough to cover the furnishing of a certain amount of water. Its advocates claim for it that it discourages any tendency to undue restriction of the use of water with consequent unsanitary conditions.

Table 5 gives examples of various forms of meter rates.

TABLE 5.

SHOWING EXAMPLES OF METER RATES.

New Britain, Conn.:

Minimum charge, $6.00 per year, includes 5 000 cu. ft.

5 000 to	100 000 cu. ft. per year at	$0.12 per 100 cu. ft.
100 000 to	300 000 cu. ft. per year at	.10 per 100 cu. ft.
300 000 to	600 000 cu. ft. per year at	.08 per 100 cu. ft.
600 000 to	1 000 000 cu. ft. per year at	.06 per 100 cu. ft.
1 000 000 or over	cu. ft. per year at	.05 per 100 cu. ft.

Sliding Scale, Frankfort, N. Y.:

Minimum charge, $7.00 per year.

First	25 000 gallons.....	$0.28 per 1 000 gallons.
Next	10 000 gallons.....	.24 per 1 000 gallons.
Next	15 000 gallons.....	.21 per 1 000 gallons.
Next	15 000 gallons.....	.18 per 1 000 gallons.
Next	20 000 gallons.....	.15 per 1 000 gallons.
Next	20 000 gallons.....	.13 per 1 000 gallons.
Next	110 000 gallons.....	.12 per 1 000 gallons.
Next	275 000 gallons.....	.11 per 1 000 gallons.
Next	500 000 gallons.....	.10 per 1 000 gallons.
Over	8 000 000 gallons.....	.05 per 1 000 gallons.

Sliding Scale, Cleveland, Ohio:

Minimum charge per year (?).

If use 2 000 cu. ft. or less.....	$1.212 per 1 000 cu. ft.
If use 3 000 cu. ft. to 5 000.....	0.571 per 1 000 cu. ft.
If use 6 000 cu. ft. to 50 000.....	0.404 per 1 000 cu. ft.
If use 50 000 cu. ft. (suburban special),	0.425 per 1 000 cu. ft.

Fixed Charge and Sliding Scale, Madison, Wis.:

$\frac{5}{8}$-in. meter.....	$3.00 per year.
$\frac{3}{4}$-in. meter.....	3.50 per year.
1-in. meter.....	4.00 per year.
$1\frac{1}{2}$-in. meter.....	5.50 per year.
2-in. meter.....	7.50 per year.
3-in. meter.....	12.00 per year.
4-in. meter.....	20.00 per year.

If more than one consumer on one meter, one dollar per consumer (extra).

Water rate:

$0.06 per 100 cu. ft. up to 150 000 cu. ft. per year.
.05 per 100 cu. ft. over 150 000 cu. ft. per year.

Ready to Serve and Straight Scale, New Orleans, La.:

Meter.	Per Year. 1912.	Per Year. 1913.
⅝ in.	$4.00	$3.00
¾ in.	5.00	3.60
1 in.	6.60	4.80
1½ in.	10.60	7.20
2 in.	14.50	12.00
3 in.	22.00	18.00
4 in.	36.00	24.00
6 in.	64.00	42.00
8 in.	97.00	72.00

All water 7 cents per 1 000 gal.

Sliding Scale, Wallingford, Conn.:

First	15 000 cu. ft.	$1.50 per 1 000 cu. ft.
Next	10 000 cu. ft.	1.25 per 1 000 cu. ft.
Next	15 000 cu. ft.	1.00 per 1 000 cu. ft.
Next	20 000 cu. ft.	.90 per 1 000 cu. ft.
Next	40 000 cu. ft.	.85 per 1 000 cu. ft.
Next	100 000 cu. ft.	.75 per 1 000 cu. ft.
Next	100 000 cu. ft.	.65 per 1 000 cu. ft.
Over	1 050 000 cu. ft.	.25 per 1 000 cu. ft.

Louisville, Ky. — Proposed Fixed Charge for Service and Fixed Rate:

⅝-in. meter	$6.00 per year.
¾-in. meter	9.00 per year.
1-in. meter	12.00 per year.
2-in. meter	24.00 per year.
6-in. meter	72.00 per year.

Catasauqua, Pa. — Readiness to Serve and Fixed Charge:

⅝-in. meter	$0.50 per month.
¾-in. meter	1.00 per month.
1-in. meter	1.50 per month.
1½-in. meter	2.00 per month.
2-in. meter	3.00 per month.
3-in. meter	4.00 per month.
4-in. meter	8.50 per month.
6-in. meter	10.00 per month.

San Diego, Cal.:

City owns meters, makes a fixed charge covering the installation of service meter and meter box. This charge covers perpetual maintenance of the installation and replacement of same in all cases when damaged and not due to direct action of consumer.

Size of Meter.	Cost of Meter and Box.	Cost of Service.	Cost of Paving.	Total Cost of Installation.
$\frac{5}{8}$ in.	$8.00	$10.00	$17.00	$35.00
$\frac{3}{4}$ in.	14.00	10.00	17.00	41.00
1 in.	20.00	12.00	20.00	52.00
$1\frac{1}{2}$ in.	37.00	20.00	21.00	78.00
2 in.	67.00	32.00	22.00	121.00
3 in.	137.00	100.00	24.00	261.00
4 in.	250.00	126.00	26.00	402.00
6 in.	500.00	166.00	30.00	696.00

All water used, charged for, 8 cents per 100 cu. ft.

The Fixing of Rates by Municipalities or States for Water-Supply Systems.

The earlier water-supply franchise in the United States either ignored the question of rates entirely, or fixed an arbitrary maximum schedule based on existing rates in near-by municipalities. In some few cases the franchise provided for a readjustment of the rates at the end of certain fixed periods. In California the State constitution prescribes that all municipalities must, yearly, by ordinance, fix the water rates that may be charged by private water corporations operating within the municipal limits. This right was called into question by the Contra Water Company which supplies the city of Oakland with water, in a case of rate fixing, and the decision given in the United States Supreme Court in 1911 states, among other things:

"That the provision of a state constitution for fixing rates annually for the use of water is sustained, on the ground that where one devotes property to public use he grants the public an interest therein and must submit to being controlled for the common good." The opinion goes on to state that the fixing of rates is a legislative and not a judicial function, and that the legislature has a right to delegate this function to some minor body, and that when a city ordinance fixing rates for a corporation supplying water is enacted in the manner prescribed by law, it cannot be set aside unless it is invalid on the constitutional ground of being confiscatory in depriving the corporation of property without due process of law.

The burden of proof resting in that case with the corporation that claims the rates are confiscatory.

The opinion states that the rates fixed must be ample to cover the following items:

(*a*) Operating expenses.

(*b*) Taxes.

(*c*) Current repairs.

(*d*) Annual depreciation of property.

(*e*) A fair return on the fair value of the property. (For what constitutes a fair return, see Table 6.)

No allowance is to be made for past depreciation, and in getting at the value of the property the corporation is not entitled to any allowance for goodwill.

That rate-making is a legislative function and may be delegated by the legislature to some subordinate or administrative body, is also covered in the United States Supreme Court decision in the Knoxville case.

In general, the courts have held that in all cases where the franchise or charter, under which a water company operates, does not distinctly specify the rates that may be charged or method of fixing the same, the right to regulate the rates rests with the legislatures and, in all cases where the matter is in doubt, the benefit of the doubt is to be taken as in favor of the public and against the private corporation.

Where rates are fixed by the franchise they cannot be diminished by the legislature, but in such cases, even where a corporation has a contract or franchise providing that no contract or privilege will be granted to any other person or corporation to furnish water to a certain city, the United States Supreme Court decided that, in the absence of a special stipulation to that effect, the city is not precluded from establishing its own independent system of water works. See 200 U. S., page 22, Knoxville.

Wilcox, in his work on franchise, advocates the taxation to death of any corporation that cannot be otherwise reached in case of unjust rates, but this method appears to be unnecessary, inasmuch as the people affected can, always, by legislative enactment, condemn and purchase the property of the offending corporation by due process of law. "Eminent domain

is superior to franchise rights. Franchise is merely property." See decisions 166 U. S., page 693; 115 U. S., page 673.

Within the last few years a great many states have placed all matters affecting public utilities, including water works, under the jurisdiction of special public-service commissions. According to the publication of the National Civic Federation, at the end of 1912, the following states had such commissions that included among their functions the regulation of water-works corporations: Arizona, California, Maryland, Nevada, New Hampshire, Ohio, Rhode Island, South Carolina, Virginia, Washington, Wisconsin, New Jersey.

In New York the State Conservation Commission, under Chapter 647 of the Laws of 1911, passes on water-supply matters.

In Massachusetts the State Board of Health covers all water-works matters.

During 1913 measures were taken in the following states either to create Public Service commissions, or to extend the jurisdiction of existing commissions so as to cover water-works matters: Colorado, Delaware, Illinois, Maine, Kansas; and during the same period the following states made changes in the existing commissions so as to give them jurisdiction in water supply matters: Idaho, Indiana, Oklahoma, Missouri, Montana, West Virginia, North Carolina, Ohio.

These commissions, with trifling exceptions, are all modeled on either the California or Wisconsin commission plan. Such variations as exist are of a minor character, and are best shown by a few examples.

Ohio excludes any value, due to franchise or merger, from consideration in rate making.

Wisconsin and Oregon provide that depreciation must be considered in fixing rates.

South Carolina provides that rates may be varied according to value of service rendered.

Before going further it may be well to give an outline of the Wisconsin and California Utility Laws, as these two may be considered the models on which the commissions of other states have been formed.

Wisconsin Public Utility Law.

Section 1797. —

M–1. Defines public utility as including every corporation, company, individual, and every town, village, or city, that now or hereafter may operate, etc., any plant for the production, transmission, delivery, or furnishing of heat, light, power, or water, either directly or indirectly to the public.

M–2. Gives the Railroad Commission of Wisconsin the right to supervise, regulate, etc., the above-defined utilities.

M–3. Provides that reasonable service must be furnished and reasonable charges made.

M–5. The Commission is given direction to value all property of public utilities.

M–8. Uniform accounts must be kept and submitted to the Commission.

M–9. Commission given the power to prescribe all forms, books, etc.

M–15. A proper depreciation account must be provided by each corporation, and the Commission has the power to determine and fix such rates of depreciation. The Commission is to provide for such depreciation in fixing tolls or rates.

Monies so provided and set aside to be carried in a special fund, and may be used either for new construction, extension, or additions; or may be invested, in which case the income from such investment is to be carried in the same depreciation fund.

M–27. All rate schedules must be filed with the Commission. No rate can be charged without consent of the Commission. No preference or favor may be shown to any one, in either rate or its collection. Penalties are attached to both taker and giver in the violations of the above rules.

M–43. Provides for hearing of complaints, etc. A municipality must appear before the Commission, and is subject to the same rules as a private corporation. Citizens have the same rights as to complaints against a municipality as against a private corporation.

M–74. Provides against competition where a utility is in operation under an indeterminate Commission permit. This applies

also to municipalities. The Commission may, after a public hearing, decide competition is necessary.

M–76. Provides that licenses, permits, or franchises granted by the Commission shall be practically indeterminate franchises.

M–87. Gives municipal councils the power to determine, by contract or ordinance, the quality and character of each kind of product or service to be furnished by a public utility inside the municipal limits, together with all terms and conditions not inconsistent with the terms of the Public Utility Law. They can also order such additions or extensions as are reasonable and necessary. All of the above powers of municipalities are subject to the review and approval of the Commission.

M–88. Provides that no passes or free service of any kind is to be given to any public official or any other person.

California Public Utilities Act.

A constitutional amendment on December 23, 1911, gave the California Railroad Commission certain powers over all public utilities. These powers are, in brief, as follows:

(*a*) Power to fix all rates, charges, and classifications.

(*b* to *n*) Relate to railroad matters only.

(*o*) Power to fix standards, classifications, measurements, and practices of all gas, electric, and water corporations.

(*p*) Power to ascertain the value of the property of every public utility.

(*r*) Power to permit or to refuse to a public-utility corporation the right to enter a field already served by a like corporation.

(*s*) Power to permit or to refuse to permit a corporation to exercise rights under new franchises or permits.

(*t*) Power to regulate transfers of property used in public service, including the acquisition by one public utility corporation of stock in any other such corporation.

(*u*) Power to regulate and control all issues of bonds, stocks, or other evidences of indebtedness within the state.

Hearings are heard without regard to the technical rules of evidence so as to get at the truth as quickly and simply as possible.

A party aggrieved by the decision of the Commission must apply

for a rehearing and give reasons for the same; and if a rehearing is refused, can appeal to the State Supreme Court for a review of the question on the evidence presented at the hearing of the Commission without any new evidence, and the findings of the Commission as to questions of fact will be considered final.

Ample provision is made for bonds to be filed by petitioners for review so as to protect those who would be injured by delay if the decision finally given is in their favor, and for impounding excess rates, etc., at interest until questions of validity are settled.

All of these provisions are drawn in such a manner as to prevent long-drawn-out legal proceedings and foolish appeals.

It is provided that all existing rights of cities and towns to fix rates, etc., are continued in form under the new law, but the Act provides that any city or town can hold an election and, on vote in favor, can turn control of all its public utilities over to the Railroad Commission.

An amendment to the Act excludes the Railroad Commission from the control of municipally owned utilities, and restricts its jurisdiction to private corporations.

Existing privileges of private corporations are exempted from Commission control, but as such companies cannot extend their operations except as allowed by the Commission, a large measure of control is possible even for these companies.

General Rules that Seem to Govern Courts and Commissions in the Fixing of Water Rates.

(1) No unmeasured water is to be supplied for any purpose.

Water supplied to public buildings, institutions, etc., to be metered.

Water for sprinkling to be measured or estimated as closely as possible.

Water for fire purposes to be based on hydrant rental. (Method of getting at hydrant rental will be considered later on.)

All of the water used for above purposes, whether supplied to a municipality by a private corporation, or by its own works, is to be paid for by direct taxation, and should not in any case be made part of the water rate paid by individual consumers.

(2) All water rates should be so figured as to provide for the following factors:

(*a*) A fair return on the fair value of the plant.

(*b*) All proper operating costs.

(*c*) An allowance for current repairs and renewals, and for taxes, if any.

(*d*) A yearly increment to provide a so-called depreciation fund.

(3) A fixed or minimum charge is to be made that will cover all overhead or capacity charges, and this minimum charge is to apply not only to individual consumers, but also to those portions of the supplies that are used for public purposes.

(4) A fixed charge for actual amount of water used, based on the actual cost of supplying the same. This charge is usually given as so much per 1 000 gal., or per 100 cu. ft.

While the general trend of opinion is to the effect that no variation should be made in the price so fixed, the practice in some localities still sanctions the use of a sliding scale with reductions in price for what may be called wholesale consumers.

(5) A hydrant rental based on the extra cost of plant, etc., required to furnish fire protection over and above what would be required to provide for ordinary consumption.

The above general principles seem to be universally admitted as correct, but in the application of them there are bound to be differences of opinions and of methods used. Before taking up the matters involved in these differences, a short summary of the methods used in Madison, Wis., and those used in New Orleans, La., are given as examples for comparison.

MADISON, WIS.

Value of the plant was fixed by the Commission, based on inventory checked by books and reports.

Value adopted, $576 188.

Interest allowed on investment, 4 per cent., as this was a municipal plant; for private plants, the Commission allows 6 per cent.

Depreciation allowance (assumed), $3 500 per annum.

Taxes allowance (assumed), $5 000 per annum.

Operating expenses were made up from averages of expenses, etc., for past years.

Coal, assumed as $11 900 per annum. (Actual for 1909, $7 891.)

Maintenance of buildings, $500 per annum. (Actual for 1909, $850.)

Maintenance of reservoirs, etc., $165 per annum.

1909.

Operating expenses	$31 184.33
Interest	23 047.52
Taxes	5 000.00
Depreciation	3 500.00
Total	$62 731.85

The Commission makes a sharp distinction between the expenses of operation, due to the capacity of the plant, and those due to actual output. The first, or capacity-expense class, is fairly constant, but the output expense naturally varies with the amount of water used. Some items partake in part of the nature of each class, and all accounts are tabulated and distributed, in a table which gives a distribution of expense made some time after the rates, established by the Commission, had been put in service.

The original determination gave the capacity charge as 49.93 per cent. of the total, which makes a nearly even distribution of expense into the two classes for this particular case. Ordinarily, it has been found that capacity charges amount to from 60 to 70 per cent. of the whole.

Capacity expenses are further divided into public and private service charges. The various items were divided, according to the judgment of the engineers, as follows:

	Public.	Private.
Reservoirs and standpipes	$18 769	$6 256
Distribution mains	144 189	187 452

The summation of all the capacity items showed a distribution of 49.6 per cent. for public and 50.4 per cent. for private service.

Output expenses were based on amounts of water used, 254 795 608 gal. being charged to private consumption, and 182 523 000 gal. to public consumption.

From the figures so obtained, the Commission determined charges or cost, as follows:

Capacity cost, $31 506.96; output cost, $30 752.67.
City should pay, $28 906.96.
Private consumers should pay $33 352.57.

The city actually had paid $1 675 interest on bonds and an allowance of $10 000 for taxes (not paid).

On the basis above outlined the rates were fixed and divided into two parts, viz., service charge based on capacity charge, outlined as follows:

$$\text{Capacity charge} = \begin{cases} \text{Readiness to serve.} \\ \text{Meter charge.} \end{cases}$$

$$\text{Meter charge} = \begin{cases} \text{Maintenance} = \begin{cases} \text{Interest.} \\ \text{Depreciation.} \\ \text{Maintaining meter.} \end{cases} \\ \text{Reading meter.} \end{cases}$$

Capacity Account Part of Meter Maintenance Cost.

Meter cost was $50 000.00.	
Interest and depreciation taken as 8 per cent	$4 000.00
Capacity charge taken as 70 per cent. of meter maintenance cost	490.00
Meter reading cost per year	508.75
Total	$4 998.75

The total capacity charge for private consumers was found to be $15 454.62. Deducting the meter charge, $4 998.75, leaves $10 457.87 as the sum that the private consumers should pay irrespective of whether water is used or not.

The meter charge of $4 998.75 was divided among the meter users as follows:

Reading 4 418 meters, $508.75, or 11½ cents per meter. The balance of meter charge was distributed according to size and cost of meter used, and gave 94½ cents for a ⅝-in. meter. The total net capacity charge divided among 5 723 consumers gives $1.82 per year, two dollars being taken as the nearest even amount.

The schedule adopted was as follows:

Size of Meter. Inches.	Per Half Year.
$\frac{5}{8}$	$1.50
$\frac{3}{4}$	1.75
1	2.00
$1\frac{1}{2}$	2.75
2	3.75
3	6.00
4	10.00

When more than one consumer is served from the same meter an addition of one dollar for each such consumer is added to the fixed meter charge.

The equitable charge to consumers, figured on their part of the output expense, should be $5\frac{1}{4}$ cents per 100 cu. ft., but the actual charge was fixed at 6 cents per 100 cu. ft. Resulting rates gave only a slight reduction to consumers.

TABLE 6.

SHOWING OPINIONS ON WHAT CONSTITUTES A FAIR RATE OF RETURN.

Iowa Supreme Court, 1902, Water Company case, 4.4 to 5.5 per cent. is not confiscatory.

U. S. Circuit Court, 1903, Spring Valley Water Co., Cal., 5 per cent. is the minimum rate.

U. S. Circuit Court, 1904, Contra Water Co., Cal., 5 per cent. is the minimum rate.

Maine Supreme Court, 1904, Water Co. case, reasonable rate of return depends on circumstances.

N. J. Chancery Court, 1905, Water Co. case, 5 per cent. is the minimum rate.

U. S. District Court, California, Water Co. case, 5 per cent. is a reasonable return.

U. S. Supreme Court, Knoxville, Water Co. case, undecided whether 4 per cent. is confiscatory.

N. Y. Court of Appeals, 1909, Jamaica Water Co., 6 per cent. is a fair return.

U. S. Circuit Court, 1909, Water Co. case, 6 per cent. is a reasonable rate.

U. S. District Court, 1911, Spring Valley Water Co., 3.97 per cent. is confiscatory.

U. S. Circuit Court, 1911, Des Moines Water Supply Co., 8 per cent. is a fair return.

Wisconsin Commission allows 6 per cent. for private plants and 4 per cent. for municipal plants.

NEW ORLEANS, LA.

From article by George W. Earle in 1911, and from yearly report New Orleans, for 1912:

The general rules adopted were that all taps were to be metered, even for the so-called free services.

All free water to be eliminated, and the general Tax Fund was budgeted in such a manner as to apportion to each department the value of the water it used.

The department keeps accounts, makes collections, reads meters, taps water mains, makes connection to and sets meter without a direct charge.

All of the above is provided for from the meter "service charge."

The cost of the water service is distributed as follows:

(1) Fair hydrant rental.

(2) Fair service charge for each size meter and connection.

(3) Fair price per 1 000 gal. of water used.

(4) Fair amount raised by direct taxation to cover so-called "free water."

Cost of works, $8 500 000.

Cost of meters and connections, $750 000.

Cost of works, less meters, $7 250 000. This cost is apportioned as 25 per cent. to fire service and 75 per cent. for all other uses.

Population, 340 000; plant capacity, 45 000 000 gal.

Miles of mains, 515; maximum filter capacity, 67 000 000 gal.

Hydrants, 5 000; pumping capacity, 100 000 000 gal.

Distribution system capacity, 80 000 000 gal.

Daily consumption was assured as follows:

Private consumers	8 400 000 gal.	} Includes under registration.	
Public and charity	3 600 000 gal.		
Fire Dept. and Public Works hydrants	2 000 000 gal.		
Leakage and sewer flushing	2 000 000 gal.		
(1) Interest and depreciation, 4½ per cent. of $5 810 000		=	$261 000.00
(2) Interest and depreciation (Fire Service), 4½ per cent. of $1 940 000		=	87 000.00
(3) Interest, depreciation, and maintenance meters		=	60 000.00
(4) Meter reading, collection, and accounting		=	40 000.00
(5) Maintenance costs distribution system		=	50 000 00
(6) Maintenance costs fire hydrants		=	10 000.00
(7) Maintenance and operation of pumping plant		=	150 000.00
Total			$658 000.00

Item 7 charge, $70 000 to output and $80 000 to capacity.

Charge for fire hydrants includes all of items 2 and 6, one fourth of item 5, one seventh of output portion of item 7, and one fourth of capacity portion of item 7, making a total of $139 500 for 5 000 hydrants, or $28 per hydrant. This is a per capita charge of $0.41 for fire protection.

Meter service charge includes items 3 and 4; it is provided pro rata according to number and size of meters. Three tenths of the total, or $30 000, is charged to public consumers, and the remaining $70 000 is charged to private consumers. To results so obtained further fixed items are added.

The service charges for the various meters range from $4 for a $\frac{5}{8}$-in. meter up to $97 for an 8-in. meter.

The total cost of water used is made up of all of item 1, three fourths of item 5, twelve fourteenths of the output portion of item 7, and three fourths of the capacity portion of item 7, and amounts to $418 500. This is apportioned 30 per cent. to public and 70 per cent. to private consumers.

The total distribution of expense is taken as follows:

	Fire. Hydrants.	Service. Charge.	Water. Charge.	Total.
Direct from taxpayers.....	$139 500	$30 000	$125 550	$295 050
Direct from rate payers.....		70 000	292 950	362 950
Totals.....	$139 500	$100 000	$418 500	$658 000

The 1912 report of New Orleans states that the water rate was 7 per cent. per 100 cu. ft. to all consumers, and that it has been found possible to make reductions in the service charges for all sizes of meters, as follows:

Size of Meter. Inches.	Service Charge, 1912. Per Annum.	Service Charge (Proposed). 1913.
$\frac{5}{8}$	$4.00	$3.00
$\frac{3}{4}$	5.00	3.60
1	6.60	4.80
$1\frac{1}{2}$	10.60	7.20
2	14.50	12.00
3	22.00	18.00
4	36.00	24.00
6	64.00	42.00
8	97.00	72.00

The actual amount of water used during 1912 for public purposes was as follows:

Schools, public buildings, etc.	392 000 000 gal.
Sewer flushing	30 000 000 gal.

This was charged at $6\frac{2}{3}$ cents per 1 000 gal.

Service rates on the above, $3 200.

Fire hydrants, 5 098, at $35; $78 430.

The total amount charged to direct taxation was $214 060, as compared with the $295 050 estimated in 1911.

Value of and Proper Charge for Fire-Hydrant Rental.

In 1903 an article by J. T. Sawyer gave the average fire-hydrant rental for the United States as $49.43, giving as his authority the Manual American Water Works for 1888.

Mr. Sawyer made up a yearly cost per hydrant for small four towns ranging from 1 000 to 35 000 population on the basis of the difference in cost between a water-supply system for domestic use only and for a combined domestic and fire service. Three-inch was the minimum size main allowed for strictly domestic service system, and six-inch for a combined fire and domestic service. Table No. 7 shows how the costs were arrived at.

TABLE 7.

Showing Sawyer's Comparison of Costs between Domestic versus Combined Fire and Domestic Water Supply Systems. (1903.)

	Population in 20 Yrs.	Miles Mains.	No. of Hydrants.	Hydrants.		Kind of System.	Total Cost.
				Per 1 000 Population.	Per Mile of Main.		
Tolono	1 000	2.74	21	21	7.7	D	$12 847.52
						D & F	25 766.89
Paxton	6 000	7.72	57	95	7.4	D	32 733.47
						D & F	58 698.91
Danville	23 000	22.23	160	69	7.2	D	60 924.65
						D & F	131 417.44
Springfield	35 000	33.77	255	73	13.3	D & F	383 818.59

TABLE 7 — (*Continued*).

	Excess Initial Cost per Hydrant.	Yearly Interest at 6 Per Cent.	Additional Yearly Cost per Hydrant.			Fire Protection. Yearly Cost.	
			Operation.	Sinking Fund.	Total.	Per Mile of Main.	Per Hydrant.
Tolono.....	$615.21	$36.91	$9.64	$12.31	$58.86	$451.09	$1 236.06
Paxton.....	454.83	27.28	12.74	6.47	46.49	343.26	441.65
Danville...	440.00	26.40	14.09	8.42	48.91	352.03	340.28
Springfield .	598.38	35.90	7.12	7.21	50.23	319.87	379.30

Note. — D=Domestic. D & F = Domestic and fire.

Mr. C. C. Brown, in commenting on the article, states that the average annual cost of furnishing fire service is about 50 per cent. of the annual fixed charges on plant, plus 20 per cent. of the actual operating expenses. The figures arrived at by Mr. Sawyer practically agree with this theory.

In 1908 Mr. D. R. Gwinn published some figures on fire-hydrant rentals without going into the matter of how same were fixed.

In 1911 Messrs. Metcalf, Kuichling, and Hawley, in the American Water Works Association, took up the question of fire-hydrant rentals in detail, and called attention to the fact that, up to that time, practically all hydrant rentals were based on the averages of the existing rates in nearby communities, or, in large cities the rental was fixed by using the existing rentals in the nearest city of about the same size. In some places the hydrant rentals were fixed to take care of the interest charges upon the necessary investment, and all other charges and profits were supposed to be derived from the regular water rates.

As to the hydrant rentals actually paid, the following figures from the last-mentioned article will serve as examples:

Average hydrant rental,	22 cities (Eastern states)	$29.38 per annum.
Average hydrant rental,	73 cities (Cent'l and S. W. states)	45.03 per annum.
Average hydrant rental,	24 cities (Southern states)	42.54 per annum.
Average hydrant rental,	6 cities (Western states)	28.42 per annum.
Average hydrant rental,	125 cities	41.05 per annum.

A certain company that supplies a number of municipalities in the Middle West had a schedule made up as follows:

Contract Time, Years.	Annual Charge for Fire Protection. Per Mile of Main per Year.	Additional per Hydrant per Year.
1	$325	$15
10	275	6
20	260	5

It is to be noted that this is a combination charge.

Another common method of paying for hydrant service is a fixed annual rental per hydrant coupled with a clause that the Water Company must furnish one additional hydrant for each 600 ft. or so of new distribution pipe laid. This method is not as equitable as would be a provision that the city shall pay a lump sum per year for fire protection and have the right to attach as many hydrants as it wants to, to the mains, upon payment of a rental per hydrant, based on the actual cost of hydrants and connections. Provision for increased rental in this case to be based either on a pro rata to the increase of population, or in proportion to distribution main mileage in the district covered.

If, however, the payment is to be based only on hydrant rental, the rational method of arriving at a proper individual hydrant rental would be to determine what percentage of the total cost of the water-supply system was made necessary in order to provide for fire protection, and add to the interest and depreciation charges figured therefrom that portion of the operating expenses that is due to the use and maintenance of the hydrants, and divide the cost so found by the number of hydrants in use.

Such hydrant rentals should be determined, if possible, at intervals of a few years, for it is evident that the hydrant rental so arrived at will not be a correct measure of the cost for very long if the municipality is a growing one.

The authors of the paper last mentioned seem, however, to be of the opinion that the rental paid should be somewhere between the cost of the service to the water company and the value to the community of the protection afforded it.

The total costs for hydrant rental should, in any event, be assessed on the community as a general tax and not be put on individual consumers in the form of an increased rate.

The actual percentage of the cost of water supply systems, chargeable to fire protection, will naturally vary owing to a

NOTE.

Insert page 27, Vol. 29.

Metcalf, Kuichling and Hawley state (Proc. Am. W. W. Association, 115, 1911), the cost of the portion of the water-works plant involved by fire hydrant service probably constitutes the following percentages of the entire cost of the physical property:

Population less than 5 000	60 to 80 per cent.
Population 100 000, more or less	20 to 30 per cent.
Population of our largest cities	10 to 20 per cent.

variety of causes, and the following extracts from Bulletin No. 148, U. S. Geological Survey, give averages arrived at from a list of 1 500 plants.

COST OF FIRE PROTECTION.

Cities, Population.	Cost per Capita.	Total Cost Water Supply of System.	Percentage Chargeable to Fire Protection. Per Cent.
All plants	$27.21	$1 129 247 532	21.75
100 000 or over	32.72	591 222 244	15
30 000 to 100 000	29.06	184 803 174	23
5 000 to 30 000	23.60	235 718 456	32
Under 5 000	16.59	117 503 268	65

The Wisconsin Railroad Commission, in determination of rates for Appleton, stated that from 40 to 50 per cent. of the entire plant cost was chargeable to fire protection. In Ashland (population, 11 594), 54½ per cent. of the capacity cost is charged to the city for water used for public buildings, institutions, etc., and for fire service.

Figures given by Metcalf, Kuichling, and Hawley* would make the percentage of entire plant cost due to fire protection service as follows:

Population, 5 000	60 to 80 per cent.
Population over 5 000, under 100 000	20 to 30 per cent.
Population over 100 000	10 to 20 per cent.

In fixing the value of the fire-hydrant rental for New Orleans, the cost of the part of the system properly chargeable to fire protection was formerly taken as being about 33.4 per cent. of the whole cost. In 1911 the cost of fire service was taken as 25 per cent. of entire cost, less cost of meters.

The above authors give a number of interesting formulæ bearing on percentages of cost of fire service, but to my mind all such formulæ are of very limited application and cannot take the place of actual observed and computed results. Along the lines of the formulæ mentioned may be considered the statement that the yearly cost of public fire-hydrant service is to be taken as $1.00 per capita, with a variation of 40 per cent. either way.

*Proc., Am. W. W. Association, 1911.

To my mind the proper form of fire-hydrant rental would be a certain lump sum per year, entirely independent of the number of fire hydrants in use, plus a fixed sum per hydrant, both of these figures to be revised at intervals of not more than five years and to be based as far as possible on average figures for that term.

The lump sum to be based on the interest, depreciation, and maintenance charges of that percentage of the plant that is chargeable to fire protection (exclusive of cost of hydrants and connections) plus the percentage of operating cost that is due to water used for flushing, fire, or other purpose through the hydrants.

The individual charge per hydrant is to be made up of the interest, depreciation, repair, and other maintenance charges, based on the cost of the hydrants and connections at the time the rental was being determined; the pro-rata cost per hydrant, thus arrived at, to be held for all additional hydrants ordered placed during the predetermined period.

The cost of private fire protection is, as a rule, not considered, as any plant large enough to take care of the public fire-hydrant service is ample for all such private service, and in most cases the cost of installation and maintenance of the private fire service is carried by the parties utilizing such service. The water used for fire purposes will be approximately the same whether it is used through the public hydrants or the private installations.

Mr. W. E. Miller, in an article on the question of charging for private fire service in Milwaukee, Wis., *Engineering News*, 1913, states that no basis exists for charging for this class of service, except what might be advocated on the basis of value received by the private owner.

As the installation of a sprinkler system is a heavy expense, and its use makes for a decreased amount of water used in putting out fires, in Mr. Miller's opinion it is only fair that no extra charge should be made, especially as the metering of the service precludes any possibility of water being stolen for private purposes.

Rates for Private Fire Protection Service.

The amount and form of rates vary, so that no tabulation can be made, and such published rates as could be found are briefly described, as follows:

Selena, Ala. (*Municipal Plant*). Forty-five dollars per private hydrant; ten cents a unit per first 100 sprinkler heads, and five cents a unit for each additional sprinkler head, all per year; minimum charge, $100 per year; sealed fire connections with $5 fine each time seal is broken except in case of fire.

Atlanta, Ga. Consumer pays for the expense of all installations, including valves, meters, testing, etc., work being done by city employees.

Rome, Ga. (*Municipal Plant*). No charge.

Kankakee, Ill. (*Private Plant*). A minimum charge of $300 per annum; consumer can use water up to amount of charge at the rate of 1 000 gal. per 10 cents.

Terra Haute, Ind. (*Private Plant*). Meter set at expense of consumer; minimum rates, $20 to $25 per month, whether used for fire protection or not.

Davenport, Ia. (*Municipal Plant*). Conditions the same as at Terra Haute. A gate valve placed on connection branch, close to main.

Lexington, Ky. No fire service over 2-in.

Battle Creek, Mich. (*Municipal Plant*).

Size of Connection. Inches.	Yearly Charge.
8	$400
6	200
4	100
3	75
2	50
1½	35
1	20

For more than one connection of the same size on the same premises, one half of the fixed charge is added for each additional connection.

St. Paul, Minn., where fire services are not metered, charges are as follows:

	Size of Connection. Inches.	Yearly Charge.
Two or less	4	$100
Each additional	4	50
Two or less	6	150
Each additional	6	75
For each	8	300
For each	10	1 000
For each	12	1 000

Meters may be ordered placed at the discretion of the water board.

Hackensack, N. J., will provide a meter with full-sized by-pass, gate on by-pass sealed, and to be opened only in case of fire, or will provide a connection without meter; sealed gate of fire connection is independent of regular supply; charge to be one half of minimum water rate for size of pipe used.

Elmira, N. Y.

Size Fire Service. Inches.	Water Allowed to be Used per Year. Gallons.	Total Cost of Service.
6	1 000 000	$75
4	750 000	50
3	475 000	35
2	400 000	25

The rates given are in addition to regular charges for water used for general purposes.

Jamestown, N. Y. (*Municipal Plant*). Free service, consumer pays cost of connection.

Erie, Pa. (*Municipal Plant*). One connection furnished to curb; size limit, 6 in.; may be used for fire service only; no charge.

Richmond, Va. Charge, $50 per year for each fire protection system; consumer agrees to use water through the fire connection for fire purposes only.

San Diego, Cal. Consumers for regular service pay a fixed sum that covers the cost of installing service pipe, meter box, meter, etc., with perpetual maintenance of the same, and where the service is used for sprinkler fire service only a proportional meter may be used in place of the standard type meter. Reductions in cost are made as follows:

	Regular Type.	Fire Service.
2-in. service and meter, complete,	$121	$94
3-in. service and meter, complete,	261	184
4-in. service and meter, complete,	402	232
6-in. service and meter, complete,	696	296

Meters are required on fire services at the following places: Worcester, Mass.; Hartford, Conn.; Belmont, Mass.; Bridgeport, Conn.

At New Haven, Conn., the right to meter is reserved.

At Milwaukee, Wis., no charge is made for fire services, but cost of connection and meter is paid by consumer.

Valuation for Rate-Making.

The valuation of a water-works property may be made for four different purposes, and need not be the same for any two of these purposes. They are as follows:

(1) Taxation.
(2) Accounting and capitalization.
(3) Public purchase.
(4) Rate making.

The first two are of no concern to us, and what little information is available on (3) has in most cases been evolved from data and experience acquired in working out valuation for rate making.

Some confusion exists as to what is meant by "value," which term is often confounded with cost. The actual cost of a thing is not necessarily a criterion of its value, and such actual cost would probably be the same for all purposes and, at the same time, not its value for any of the purposes for which a valuation was to be made.

The leading case from which most of the present data on rates has been developed was that of Smyth *v.* Ames, in 1898 (U. S. 18 Sup. Ct. 418, 42 Led. 819, March 7, 1898). The United States Supreme Court therein clearly decided "that a fair return on the fair value of the property used for the convenience of the public was the chief basis for the determination of the reasonableness and the constitutionality of a rate." Since that time various courts and commissions have ruled that specific elements of a valuation may vary with the purpose for which such valuation is made.

U. S. District Judge Farrington, in the Spring Valley Water Co. case, 165 Fed. 667–696, October 7, 1908, ruled that value for taxation is not admitted as evidence of value for rate purposes. The United States Supreme Court ruled that value fixed for taxation was not material in fixing on value for rates (Wilcox *v.* Consolidated Gas Co.).

The Wisconsin Railroad Commission has ruled the same way.

The Indiana Railroad Commission takes the same position.

Mr. Whitten, in his book, "Valuation for Rate Making, etc.," states that the fundamental distinction between valuation for taxation or accounting on the one hand and for rate making or condemnation on the other hand, is that the first group is subject to legislative control, as no constitutional rights are involved, but that valuation for either rates or forced purchase is subject to review by the United States Supreme Court.

The question arises, "What is a fair value for rate making?" The answer is not easy to find in any case. Judge Farrington, of the U. S. Supreme Court, in a decision on rates, states, in substance, as follows:

(1) The cost of reproduction is not a fair measure of value unless a proper allowance is made for depreciation. All parts of a plant are subject to wear or decay.

(2) The original cost is not in all cases a fair criterion of value. The plant may have cost too much or not have been properly adapted for the purpose intended. It may be too large.

If an increase in value of any part has taken place, the corporation is entitled to a fair return on such increased value, provided such return does not mean an unjust or unreasonable charge to the public.

(3) The aggregate market value of stocks and bonds is not, as a rule, a reliable index of fair value of the plant, as such market values are too often simply the result of manipulations.

Other judicial opinions are to the same effect.

In general, the courts and commissions have refused to commit themselves as to what constitutes a fair value for rate making, and have adopted as a leading factor one of the following standards, and used the others as a sort of test or check on the value so desired:

(1) Actual cost method.
(2) French method.
(3) Market value method.
(4) Cost of reproduction method.

The following actual rate cases give an idea of the process used by the Wisconsin Commission.

Hill *v.* Antigo Water Co., August 3, 1909, 3 W. R. C., R. 623:

Cost of reproduction, new, plus bond discount	$102 860
Above, less depreciation	95 077
Earning value on a 6 per cent. basis (market value)	95 282
Earning value on a 4 per cent. basis (market value)	119 464
Going concern value addition	7 000 to 10 000
Allowed commission valuation	110 000

Ontario City Water Supply Co., August 7, 1911:

Cost reproduction, new	$126 648
Cost reproduction, less depreciation	116 547
Actual investment	139 400
Allowed commission valuation	125 000

ACTUAL COST METHOD.

The preliminary report of the Special Committee on Valuation of Public Utilities of the American Society of Civil Engineers favors the cost of Reproduction Method for old properties, but also favors providing by law " that future public service properties should be valued on the basis of their actual reasonable investment; all additions and replacements to original plant to be added to such original valuation, and all amounts allowed for depreciation to be deducted."

Mr. Whitten states that where Actual Cost Method is used, it should be original cost, plus all additions and betterments, inclusive of renewals and replacements. Where reference is made in court decisions to actual cost, they have, in many cases, loosely interpreted the term so as to include such items as discount on securities issued, profits to promoters, cost of replacements, dividends paid out of capital, etc.

Mr. Whitten considers actual cost, when properly determined, as the fairest method of valuation for rate purposes, but admits that it is very hard, and in some cases impossible, to determine it.

The Interstate Commerce Commission, in 1911, accepted actual cost as a basis for rates.

Connecticut Public Utilities rejected this method in 1912.

FRENCH METHOD.

A method of arriving at the fair value of a plant that has been used in some Wisconsin cases, and by the French and Swiss governments in taking over railroad systems, and which might be used

for first valuation rate cases where a proper accounting system has been in use from inception of the plant considered, is described by Bion J. Arnold in an article on Valuation of Street Railroads in Kansas City, as follows:

Find each year the actual investment in property, deduct the value of superseded property in the year it was superseded, and estimate a fair return on this net investment.

Deduct from such return the net income after paying all operating expenses, including maintenance, renewals, and taxes, charging to operation, however, the cost of superseded property in the year when superseded.

Then compound each year the deficit or surplus, as the case may be, between the fair return and net income. The result will show a sum representing the accrued loss estimated upon the basis of a return at a given rate per cent.

The total of the accrued loss, plus the actual investment, will be the fair value of the entire property, or, in case an excess or total accrued gain is shown, it should be deducted from the amount of the actual investment for a fair value of the property.

MARKET VALUE METHOD.

The market value theory recognizes the fact that a business must be valued as a single unit, and that such a business is worth what a responsible bidder will offer. The appraisal on this basis is merely an estimate of the amount that normally would be offered in open market. Mr. Whitten states that reasonable rates cannot be based on market value, as such market value is based on rates, and it would be a case of reasoning in a circle. While market value is not, and cannot be, a standard for rate making, it finds its use occasionally in the valuation of a misplaced or partially obsolete plant.

Judge Brewer, 154 U. S. 362–14, Sup. Ct. 1047, 38 L. ad 1014, May 26, 1894, says: " Equal protection of laws and the spirit of common justice forbids that any one class should be compelled to suffer loss so that others may make a gain."

The report of the special committee of the Am. Soc. C. E. is not favorable to the use of the market value standard, but admits that it was formerly largely used.

COST OF REPRODUCTION STANDARD.

The first question that arises under this method is whether the valuation shall be on the basis of actual duplication of the existing plant, or on the basis of a plant of modern design that will be capable of producing the same results as the plant to be valued.

The Am. Soc. C. E. special committee advocates the identical plant method and gives the following grounds for its view:

(*a*) General weight of court decisions favor this method, but no actual decision.

(*b*) Eliminates personal element in deciding what would constitute a proper substitute.

(*c*) Past allowances for depreciation have generally not been large enough to make it just to use substitution method.

(*d*) Adoption of substitute theory would greatly increase depreciation charges to be met in early stages of plant development.

Mr. Whitten states that the cost of reproduction does not necessarily mean cost of exact duplication.

The courts in several cases have ruled that the cost of reproduction can be used as for a plant of similar character and efficiency. In many cases it is impossible to provide an exact duplication, and, to my mind, the decisions of the courts do not intend a rigid adherence to exact duplication, but give latitude for such substitution as may be made necessary by types of plant parts that could not be duplicated in open market at the time of valuation.

The next question is that of costs. Should present prices and conditions be used, or should the prices and conditions obtained at the time the plant was constructed be used?

Mr. Whitten favors actual physical conditions at the time the plant was built, but does not commit himself as to prices.

The Am. Soc. C. E. special committee favors using original physical conditions, but the prices to be those ruling at the time the valuation is made, and quote a number of instances to support their view. On the other hand, in some recent rate cases where valuation of mains laid originally in streets not paved was involved, the present period condition was allowed for in fixing the valuation. (See Wilcox *v.* Consolidated Gas Company.) In general, it seems

to me that present prices and conditions should rule as the fair value of a plant, for rate making is not what it would have cost in the past, but what it is worth or would cost now.

The other points that arise in the matter of physical valuation are:

(1) Valuation of land.
(2) Invested surplus.
(3) Unused property.
(4) Excessive investments.
(5) Average or actual price.
(6) Overhead charges.
(7) Discount on bonds.
(8) Working capital.
(9) Piecemeal or unit construction.
(10) Physical depreciation.
(11) Depreciation of overhead charges.
(12) Functional depreciation.

The question in all the above points is, What allowance, if any, is to be made for the same, and how is it to be arrived at?

(1) *Valuation of Land.* The few cases decided that take up this matter vary, and the courts are not all agreed as to just what value should be taken. In the Consolidated Gas Company case, 212 U. S. 19–52–29, Sup. Ct. 192, 53. Led. 352, January 4, 1909, the present value of the land was taken. The Am. Soc. C. E. special committee appears to favor original cost in some cases.

To my mind, the stand taken by Alton D. Adams in his article on valuation of water works, *Municipal Journal*, June 20, 1912, is the most logical one. He calls attention to the fact that often the increased value of land occupied by pumping stations, etc., which is due to increase in value of residential or business property in the vicinity, could only be realized by the loss of and by removal of the buildings and machinery now on the land in question, and he favors only such land value allowance as would equal the cost of acquiring property having the same utility value for the plant purpose as that which is now in use.

Here again each individual case must be judged on its own merits.

(2) *Invested Surplus.* The Pennsylvania Supreme Court decided in some water company cases that the corporations were entitled to a fair return on all additions built out of surplus earnings.

The Maine Supreme Court decided that the owner is entitled to present value of his plant.

(3) *Unused Property.* The Wisconsin Commission excludes from valuation all property that has been superseded, but excepts from this ruling such property as is retained for emergency or reserve purposes.

United States District Judge Farrington ruled, in a San Francisco water-rate case (1911), that "only that property is to be considered which was then used and useful in supplying water."

Other decisions of the United States Supreme Court are to the same effect.

The special committee of the Am. Soc. C. E., while in general agreeing that the court decisions are wise and just, feels that in certain cases it would be poor policy to enforce this view in cases where a wise provision had been made in parts of a plant for reasons of ultimate economy or to provide for a probable growth in the near future. Where matters of land and water rights are involved, they consider that, if excluded from valuation when first bought, they should enter into the valuation when put into use, not at purchase price, but at the value at which they have arrived at the time of using.

A. D. Adams, in his paper on valuation, expresses the opinion that the following property should not be considered in a valuation:

(*a*) Equipment of such a nature that no one would think of duplicating, such as discarded early types of pumping engines.

(*b*) Equipment that has been superseded by better or larger equipment, as, for instance, an intake and pipe in a supply from the Great Lakes was discarded, even though in proper condition, by reason of a larger intake and pipe that had been put into service.

(*c*) Abandoned parts of plant or sources of supply, as, for instance, a group of artesian wells that cost a large sum were not valued because, though still owned by the water company, their use had been abandoned for a better source of supply.

(4) *Excessive Investments.* This item is practically covered by what has been said under the head of unused property. In special cases allowance may be made for possible immediate growth and consequent requirements.

The United States Supreme Court in the San Diego case decided against allowances for such parts of plant as they considered larger than were required.

The New Jersey Chancery Court in the Long Branch case made a large deduction from plant valuation on the same grounds.

(5) *Average or Actual Price.* Most of the commissions, instead

of taking prices of material and labor that prevail at the time of valuation, use an average of such prices for periods of from 5 to 10 years. In general, the Am. Soc. C. E. special committee's report agrees with this practice.

(6) *Overhead Charges.* Under this head are included:

(*a*) Promotion expenses.

(*b*) Engineering and superintendence.

(*c*) Contractor's profit.

(*d*) Interest during construction period.

(*e*) Legal and incorporation expenses.

(*f*) Taxes.

(*g*) Insurance.

No fixed rule governs the allowances made for the above items. The various commissions have allowed anywhere from nothing to 12 per cent. of the physical valuation to cover such items, interest being not included in the amounts so given as it is generally considered by itself.

The special Am. Soc. C. E. committee gives some figures in connection with the overhead charge items showing percentages actually expended for some of the charges included under this general heading, and advises the use of the actual original figures wherever possible, as local conditions and difficulties affect the allowable percentage to such an extent as to preclude a fixed rule relative to what is a proper allowance. They favor allowing interest from inception of work to time of actually going into service at the interest rate prevailing at the time of valuation.

(7) *Discount on Bonds.* The Wisconsin Commission has made an allowance for this item in some cases but has not made it a rule to do so.

No authority for such allowance exists in any court decision.

(8) *Working Capital.* This includes all expenditures for stores, supplies on hand, and a sufficient fund to bridge the gap between outlay and reimbursement in the early stages of operation. This item is generally allowed for in all valuations.

(9) *Piecemeal or Unit Construction* is a factor only when the valuation is based on actual construction cost and, as such, affects in that case only the unit prices.

(10) *Physical Depreciation.* In the whole subject of valuation

there has not been one single factor that has been the subject of as much discussion and disagreement as the matter of physical depreciation, not so much on that factor itself as on how its extent and effect on general valuation shall be determined. The methods in most general use are as follows:

(*a*) Sinking Fund Method.
(*b*) Straight Line Method.
(*c*) Equal Payment Method.
(*d*) Actual Appraisal Method.

Before taking up these methods in detail it may be well to go into the matter of depreciation itself.

Physical depreciation, for rate purposes, is the lessened utility value caused by physical deterioration or by lack of adaption to function.

As the operation of a public utility is a continuous enterprise, it is the right of the consumers to demand that the annual charges attributable to investment shall be as uniform as possible. These charges include repairs, removals, and replacements needed to keep the plant in good working order. In other words, the allowance for these items should, if possible, be uniform, and in any case should be ample to keep the plant at one hundred per cent. efficiency and to provide for complete replacement of actual capital invested.

The utility value of a plant is dependent on the work that it can perform during its remaining life plus its scrap value, if any. Depreciation, while it is based on deterioration, is, nevertheless, not the same thing. A rail worn fifty per cent. is deteriorated fifty per cent., but the depreciation is much greater. The special committee of the Am. Soc. C. E. has expressed itself on this subject as follows:

"Depreciation is not a lessening of worth for rate-making purposes if the property is kept up to one hundred per cent. efficiency, although it is recognized that there is a lessening of worth for the purposes of sale."

"The yearly amount which the corporation is entitled to earn from the rate payers for depreciation is, with exceptions, the sum necessary for replacing items of property that have become worn out or obsolete, and it is commonly stated that the yearly depreciation is an operating expense."

"The water-works engineer dealing with long-lived properties which infrequently require replacements, but come to the end of their lives through inadequacy or obsolescence, recognizes that the allowance for depreciation, if equivalent only to the cost of replacements from year to year, would be wholly inadequate; that is, the total amount received in the first twenty or thirty years would be very insignificant compared with the lessening of worth of the original items of the property."

The United States Supreme Court in the Contra water case provides for both a depreciation fund and an allowance for yearly replacements or repairs in its decision.

Provision for depreciation is mandatory for rate making in the following two State Commissions:

Oregon — "Must provide for in fixing rates."

Wisconsin — "Shall provide for in fixing rates."

In general it may be stated that wherever depreciation is allowed for in fixing rates, no provision is made for past years, and the yearly allowance made is based on the remaining life of the property at the time of fixing the rate.

Sinking Fund Method. This method assumes that an amount is set aside each year, and invested so that at the end of the life of the property covered it will, with compound interest, represent the cost of the said property.

The depreciation at any time is said to be equal to the amount that is or should be in a fund so accumulated.

This method will, in every case, give less depreciation than by the Straight Line Method.

The Wisconsin Commission has stated that, while there is no actual connection between the rate of depreciation and the rate at which money can be accumulated in a sinking fund, it is reasonable to assume that the four per cent. sinking fund curve fairly represents the progress of depreciation under average conditions.

In the uniform system of accounts for water-supply corporations which was adopted in conference by the following bodies: American Water Works Association, New England Water Works Association, U. S. Bureau of Census, American Association of Uniform Public Accounting, Ohio Bureau of Public Accounting, — it was stated that while it was impossible to frame concise general rules for making depreciation allowances, they would

recommend that physical examinations and appraisals should be made at intervals not exceeding ten years, so as to provide a basis for an estimate of the annual loss chargeable to depreciation. In the absence of and pending the obtaining of this data it will be assumed that the depreciation takes place according to the average life of the parts of a water-supply system and of the life of the system as a whole. They assume, as such, life for —

Horses, carriages, automobiles, and laboratory apparatus and appliances, ten years.

Office furniture and general operating equipment, fifteen years.

Boilers, steampipes, and filtration equipment, twenty years.

Engines, pumpimg machinery, and wooden pipes, twenty-five years

Masonry of filtration plants, crits, cast-iron water pipes, intakes and connections, fire hyrants, standpipes and buildings, fifty years.

Reservoirs, tunnels, and aqueducts, one hundred years.

Water supply system as a whole, fifty years.

Current depreciation of the system as a whole is approximately two per cent. of its total original cost.

In the absence of more definite data, the life of the various parts, as above given, can be used for the Sinking Fund Method as well as for the Straight Line Method.

Straight Line Method. This method assumes that the wearing value decreases uniformly each year during the entire life.

For a life of ten years, one tenth of the value represents the depreciation for each year. This method is largely used in purchase appraisals and has the merit of simplicity; it is particularly simple when what is known as the "fifty per cent. method" can be applied.

This is used where a plant or system has been built up in a piecemeal fashion; all parts being, after a cycle or two, fairly evenly distributed as to age, the appraiser can use the fifty per cent. Straight Line Method without involving much error. The method, however, is more applicable to railroad than to water-system valuation.

Equal Payment Method. This method is advocated in the preliminary report of the Special Committee on Valuation for Rate Making of the Am. Soc. C. E., and is simply an adaptation

of what is generally known as the Sinking Fund Method. The committee admits this in its definition of its method, which is a combination of the depreciation charge with the return on investment so as to form a uniform yearly charge to cover both items.

To illustrate, take an item of $100 to cover original cost of a part having a life of twenty years. By the Sinking Fund Method the annual depreciation allowance at 5 per cent. would be $3.02; the annual interest on the original investment at 5 per cent. would be $5.00; total yearly allowance for interest and depreciation, $8.02.

By the Committee Method the depreciation during the first year is $3.02, which leaves a depreciated value of $96.98 at the end of the first year, and a charge of $8.02 for interest and depreciation. At the end of the second year the depreciation is $3.18, and the interest on the $96.98 value at 5 per cent. would be $4.84, making a total of $8.02, as before, for interest and depreciation. However, where the allowed return on capital invested is figured at a greater percentage than is allowed in the depreciation fund earnings, the yearly payment will be a gradually diminishing one.

Actual Appraisal Method. This method is the one that was commonly used prior to scientific investigations of the subject, and is still made use of as a check on the results obtained by the other methods.

Of all the methods described, it would seem to the writer that for the valuation of an old plant being appraised the first time for rate-making purposes, the most logical would be the Direct Appraisal Method, the only drawback being that the personal equation of the appraiser must needs be a factor to be reckoned with.

In these days it would not be hard to arrive at a proper cost of reproduction of the plant with elements very nearly approximating in age and wearing value those in use, and by comparison with the cost of a new plant determine the accrued depreciation.

The so-called Sinking Fund Method applies more particularly to the fixing of the annual depreciation allowance that must be provided for by the rates to be charged. The method proposed by the Am. Soc. C. E. committee gives, in effect, the same re-

sults as the Sinking Fund Method, but as it combines with the depreciation an element that is not necessarily allied to it, i. e., interest on investment, I do not consider it of any especial value.

(11) *Depreciation of Overhead Charges.* In general, this item is not allowed for. The Washington Commission in the Seattle case stated "that depreciation affects only property that wears out, becomes obsolete or inadequate, and requires replacement, and indirect items are therefore excluded from annual charges." In the valuation itself they are considered as having 100 per cent. value. The Wisconsin Commission depreciates overhead charges with the property.

The N. Y. Public Service Commission, 1st District, disallows depreciation on interest and taxes during construction, but allows all other overhead charges to be depreciated with the property.

Many of the overhead charges do not have to be repeated as the various parts and structures are replaced, but those that do have to be repeated, such as engineering and contingent charges of that sort, should be depreciated.

(12) *Functional Depreciation.* This item covers lack of adaptation to function or the replacing of structures, etc., that have become poorly adapted to their work. Supersession or the replacement of structures that have become inadequate before being worn out can be foreseen and provided for by a reserve fund made up as part of and from the operation expenses charges. In these cases the capital cost cannot be charged with both the new item and the one it supersedes. In valuation for rate purposes, or public purchase, all actually accrued functional depreciation should be deducted from cost, new.

In arriving at the valuation of a plant for purchase, all recent opinions seem to indicate that depreciation must be taken into consideration, while in valuation for rate fixing no fixed rule has been arrived at. The Wisconsin Commission, in its earlier cases, used the cost of reproduction, new, but since 1909 has used cost of reproduction less depreciation. Various other commissions and boards have given decisions, some in favor of the first, and others in favor of the second of these methods. The general trend in recent years, however, has been in favor of cost of reproduction less depreciation.

Going Concern Value. As a rule no allowance is made for this factor in rate making. As the value of a business, as a going concern, is based on its income, which in turn depends on its rates, it can readily be seen that this factor cannot properly enter into the subject of rate making. A few decisions are quoted merely to show that even in this matter no uniformity exists.

Cedar Rapids, Ia., Water Company — Going concern value not allowed.

Urbana, Ohio — Fourteen per cent. allowed for going concern value.

Knoxville case — U. S. Supreme Court expressly states that it expresses no opinion on the subject.

Des Moines, Ia. — Ten per cent. allowed for going concern value.

Oakland, Cal., 1911 — Going concern value not allowed.

Wisconsin Commission, both for rates and purchase, holds that certain costs of development during the first years of a plant's existence may be added to the cost of the physical plant and form a going concern value. To my mind they are simply giving another name to what has heretofore been described as overhead charges.

Franchise Value. Very few rate cases have given any support to the theory that a franchise should be capitalized, and included in the value upon which the rates are based.

In two California cases, — Spring Valley, 1903, and Stanislaus, 1911, rate cases, — the franchise value received theoretic recognition, but no franchise value was actually included in the valuation.

The Wisconsin Commission ruled in the Antigo case that no franchise value was to be allowed other than the amounts the company actually paid to the municipality for its franchise.

General Conclusions. In making up water rates the following items must be allowed for:

(1) Interest and profit on the fair valuation of plant.
(2) Taxes.
(3) Operating expenses.
(4) Repairs and minor renewals.
(5) Depreciation allowance, physical and functional.

The fair value of a plant, whether Original Cost or Reproduction Method is used, must be lessened by the depreciation that is due

to the elapsed life of the plant parts. This depreciation allowance must be taken to cover both physical and functional depreciation. In getting at this fair value in a first appraisal for rate making, the main and only concern of both the public and the appraiser is, what is the plant worth now, and not what part of it represents capital actually invested, and what was paid for by past earnings of the plant. If part of the past earnings were reinvested by the owners in making additions or extensions, they are entitled to the values so created; if, on the other hand, they used up all the earnings in dividends, part of their investment has been returned to them and they cannot expect the public to allow them for past depreciation in the new rates.

As to future depreciation allowances they should, in all cases, be carried as a separate account, and if part or all of this money is invested, as for extensions and additions, it must be considered both as new capital invested and, at the same time, be considered as so much old capital repaid. With a proper system of accounting it will be an easy matter to make a revaluation every five years and, in a decade or two, the proper allowance for depreciation will be arrived at. To my mind the term "depreciation" is a misnomer, and this allowance should more properly be called amortization fund and be kept separate from the allowance made for repairs and minor renewals. This last allowance should be ample to keep the plant at one hundred per cent. efficiency.

The yearly depreciation allowance, pending the tabulation of actual data, should be based on the Sinking Fund Method, using as the total life of the parts the figures given on page 41. The fund so accumulated should be used in the case of a municipality to retire the bonded indebtedness and consequent valuation of the plant. For a private plant it may be used as its owners see fit, provided, however, that the account of same is kept as before outlined.

No free water of any kind should be furnished. All water used for charitable or public purposes to be charged for at the uniform rate, and all such supplies to be metered or otherwise properly measured, and the cost of such water to be provided for by general taxation.

The cost of water used for fire purposes and the yearly expenses

of that portion of the plant that is made necessary to supply same must be determined and also provided for by general taxation.

All supplies should be metered and a fixed charge to be made for readiness to serve with a uniform charge per 1 000 gal. or 100 cu. ft., as the case may be.

The water works should own and set all meters, the cost of the same to be provided for in a readiness-to-serve charge.

A city water department should, for accounting purposes, be considered apart from all other city departments, and be carried on so as to be a business on a paying basis, i. e., its rates must provide for all its expenses including interest, and provide such profit as will take care of casualties, etc.

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ELECTROLYSIS AND ITS MITIGATION. AN ACCOUNT OF THE WORK OF THE BUREAU OF STANDARDS ON THE SUBJECT OF THE DESTRUCTIVE EFFECTS OF ELECTRIC CURRENT ON REINFORCED CONCRETE AND UNDERGROUND PIPES AND CABLE SHEATHS, AND THEIR MITIGATION.

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INTRODUCTION.

The investigations of the Bureau of Standards on the general subject of the damage to underground pipes, cable sheaths, and reinforced concrete, by electric railway current and soil corrosion, have been carried on during the past four years.

The attention of the Bureau of Standards was first called to the importance of a study of the effects of electric current upon reinforced concrete by letters from engineers and companies seeking information as to the extent of the damage produced and the most practicable means of preventing it. Laboratory experiments had shown that under certain circumstances an electric current flowing from the reinforcing material into the concrete not only caused serious corrosion of the reinforcing metal, but sometimes also split open considerable blocks of solid concrete. These experiments had been repeated and confirmed by numerous experimenters, but theories to account for the phenomenon were conflicting and opinions as to the extent of the danger in practice were very diverse.

The corrosion of gas and water pipes by electric currents flowing from street railway tracks through the earth back to the power-houses was another phenomenon of electrolysis that for many years had been causing serious concern to the gas and water companies, and in more recent years at least to railway engineers also. It was recognized at the Bureau that a thorough investigation of these questions, for the purpose, first, of understanding the phe-

nomena better and, second, of learning the best methods of overcoming the trouble, would be of great practical value, and it was believed that such a problem, requiring years of consecutive observation and research, could be undertaken to advantage by a national institution, such as the Bureau of Standards. Accordingly, a special appropriation was asked for and granted by Congress, and work was begun in the summer of 1910. A number of related investigations have been carried out during the past four years, and some are still in progress.

Corrosion of Reinforced Concrete.

The investigation of the effects of electric current upon reinforced concrete was one of the first to be taken up. At the outset a number of experiments described by previous investigators were repeated in order to verify their results or to decide between conflicting conclusions. Numerous modifications of these experiments, and many entirely new ones, were instituted, and a very careful record kept of all details of the work, so that conditions could be accurately reproduced. The conditions under which an electric current can split open a solid block of reinforced concrete were investigated and the cause of this important and somewhat startling phenomenon was determined. It was also found that when an electric current flows through reinforced concrete toward the core there is an important cathode effect, such that the bond between the concrete and the reinforcing metal may be destroyed and the concrete cease to be reinforced. In addition to ascertaining the chemical and physical changes which occur, and clearing up certain hitherto unexplained phenomena, some practical conclusion of great economic value resulted from the Bureau's work. I cannot take time even to mention the principal results obtained, but can merely refer any one who is interested to our technological publication No. 18, an illustrated paper of one hundred and thirty-six pages.*

Electrolytic Corrosion of Iron in Soils.

A second investigation was on electrolytic corrosion of iron in soils, a subject of great practical importance because of the

*Sent free on request.

enormous quantity of iron gas and water pipe buried in the ground. For convenience we use the term "electrolytic corrosion" to indicate the corrosion caused by the discharge of an electric current which enters the metal from external sources. Other forms of corrosion, in which the currents originate in the corroding system from whatever cause, are designated as self-corrosion. These two forms of corrosion are not independent of one another, since the presence of either kind of corrosion generally affects the extent of the other. This mutual influence is of great importance, and must be carefully taken account of in electrolysis surveys. It is partly because of this effect that corrosion efficiencies greater than 100 per cent., sometimes as much as 150 per cent., are encountered; that is, the amount of the corrosion due to a given electric current may be as much as one and a half times as great as the amount calculated from Faraday's law, after deducting the natural corrosion that would have occurred if there had been no external current flowing. These cases occur with low-current densities. With high-current densities the efficiency of corrosion is relatively low, the iron tending to become passive, and showing corrosion efficiencies sometimes as low as 20 per cent. This is in marked contrast to the effect in concrete, where at high current densities the destructive effects increase more rapidly than the current increases.

Moisture has a marked effect, the efficiency of corrosion increasing with the moisture content of the soil up to saturation.

Temperature changes within ordinary ranges have no important effect upon the efficiency of corrosion. Temperature does exert an important influence in the total corrosion in practice by affecting the resistance of the soil.

The amount of oxygen present has a marked effect upon the end products of corrosion. If the corrosion is rapid and the supply of oxygen is limited, there will be a preponderance of magnetic oxide; if the rate of corrosion is slow and the supply of oxygen is plentiful, ferric oxide will predominate. Thus the nature of the oxide is an indication whether the corrosion is due to external electric currents, as rapid self-corrosion is unusual unless in the presence of cinders, coke, or chemicals.

Careful experiments were made to ascertain whether the effi-

ciency of corrosion is different in different kinds of iron. Eighty specimens were employed, twenty each of ingot iron, machinery steel, wrought iron, and cast iron, half of the latter being used as they came from the mold and half machined to a clean surface. The results showed almost exactly the same corrosion due to the current, although the self-corrosion of the cast iron was greater than for the others, being about 10 per cent. of the electrical loss. (The self-corrosion of the ingot iron was 3 per cent.; of the machinery steel, 4 per cent.; of the wrought iron, 5 per cent.) The superiority of cast iron respecting electrolytic and self-corrosion is due to higher resistance of the joints in the pipe lines, higher electrical resistivity of the iron, heavier walls of the pipe, and a tendency to corrode more uniformly.

Other subjects investigated were the causes of the efficiency of corrosion exceeding one hundred per cent.; the corrosion efficiency at very low voltage; and the effect of moisture content, temperature, and pressure on earth resistance. It was found that the corrosion efficiency does not vary with voltage, the current being the same. Impressed voltages as low as 0.1 volt gave the same values as 1.0 volt. Corrosion tests on a large number of different kinds of soil from widely different sources with average moisture content and moderate current densities showed that corrosion efficiencies between 50 and 110 per cent. may usually be expected under most practical conditions.

Electrical Resistance of Soils.

The resistance of soils varies widely according to the moisture content, the resistance of comparatively dry soil being several hundred times the resistance of the same soil at saturation. Hence voltage surveys should not be made at times when the earth is exceptionally wet or exceptionally dry.

The resistance of the soil varies greatly with the temperature. At —18 degrees Cent., the resistance of soil was found to be over two hundred times as great as at +18 degrees Cent. At freezing temperature the resistance is many times the value at 18 degrees Cent. This has an important bearing on the magnitude of electrolysis troubles, and shows that the damage from electrolysis

due to street railway currents may be less in winter than in summer, even though the railway currents are then greatest. The rail resistance is least in winter when the soil resistance is greatest; both tending to lessen the current in the pipes. Electrolysis surveys, therefore, would better not be made in severely cold weather.

These results have an important bearing on electrolysis mitigation, and the fixing of limiting values to the current density in rails or voltage gradients in the earth, as well as an important bearing on the methods employed in electrolysis surveys.

Nearly a hundred samples of soil were collected from various cities, including Philadelphia, Pittsburg, Erie, St. Louis, and Washington, and their resistances measured. The soil samples of each city were from widely different locations, being taken from the depth at which pipes were buried and generally near gas or water pipes. The resistances varied through a wide range, according to the character of the sample, but the averages showed some interesting results. The values were much more uniform and lower in the St. Louis samples than in those from other cities, the smallest being 400 ohms per cu. cm., and the largest 1 800 ohms. The average resistance of 35 samples of St. Louis soil was five times less than of the 20 samples of Philadelphia soil.

These results also have an important bearing on the question of damage from electrolysis and the precautions necessary to protect gas and water pipes and cable sheaths from destruction by street railway currents. The Bureau had made electrolysis surveys in Philadelphia and St. Louis, and we had wondered why the former city was relatively so free from trouble due to electrolysis. There were differences in conditions in favor of Philadelphia in several particulars, but not until we found the great difference in soil resistance did we understand the great difference in electrolysis troubles.

The proposal to fix by state law a general requirement as to voltage drop or current density in the rails is seen not to be very logical, in view of the great variations in the damage which can result under different conditions with the same voltage drops. The full results of this investigation on electrolytic corrosion of iron in soils are contained in our technological paper No. 25. The

methods employed in measuring the resistance of soils and the results obtained will be published shortly in technological paper No. 26.

Surface Insulation of Pipes.

The fourth investigation in this series undertaken by the Bureau was on the surface insulation of pipes as a means of preventing electrolysis.

One of the first methods resorted to as a means of preventing damage to buried gas and water pipes by electrolysis and soil corrosion, and still used to a considerable extent, consists in covering the surface of the pipes with a coating intended to insulate them from the surrounding earth. In many cases pipes have been so protected from soil corrosion; but it is doubtful whether there is any instance on record where damage by electrolysis has been effectually prevented in this way if the voltage conditions were at all severe. On the contrary, there have been cases where such coatings have done actual harm, as they tend to fail in spots and so permit the current to escape from the pipes at such places with a greater current density than otherwise, and so aggravate the local damage.

To obtain reliable information as to the practicability of protecting pipes from electrolytic corrosion by means of paints or wrappings, the Bureau undertook an extensive investigation of all the materials on the market for the purpose. The materials available may be divided into three classes, as follows:

(1) Paints or compounds applied at ordinary temperatures.

(2) Dips or compounds to be applied hot, such as asphalts, coal-tar pitches, etc.

(3) Wrappings, consisting of alternate layers of compound and fabrics.

(In addition, experiments are in progress on fiber conduits, used with or without pitch filling, and made up with screw joints, and pipes with enamel coatings.)

Time does not permit me to describe the experiments carried out through a period of several years, partly in the laboratory and partly on specimens buried in the earth, but I can give briefly the conclusion, namely, that the paints, dips, and wrappings

tested were found to be of little or no value in protecting pipes from electrolysis when applied to the positive areas near power stations where the current is tending to leave the pipes. Repeated experiments have shown that all the materials tested increase in weight when immersed in water. Hence they absorb moisture in greater or less degree when buried in the soil, and so become slightly conducting. Experiments show that before breaking down they begin to transmit current. This small current generates more or less gas, which soon develops pressure enough to rupture the coating. In the anode specimens, rust spots appear at the places where failure occurs, and pits then rapidly develop. In cathode specimens gas breaks through the insulating film, although no rust occurs.

These coatings would be of greater value in negative areas, where the current is flowing toward the pipes; but in practice it is not possible to foresee what are to be positive and what negative areas, for changes may at any time be made as the railway distribution system is enlarged or altered. Where there are no appreciable earth currents, and protection against self-corrosion is desired, these coatings and wrappings may be used.

After very thorough and careful study of the problem with the coöperation of many manufacturers of the materials tested, the Bureau has come to the conclusion that money can be expended more profitably in other directions than in an attempt to insulate gas and water pipes from the earth. The full results of this investigation are contained in our recent technological paper No. 15.

Insulating Joints.

A fifth investigation in this series is on insulating joints and their effectiveness in reducing trouble due to electrolysis. There are great numbers of insulating joints of various kinds in use in gas pipe lines, the most common being cement joints. This was one of the first investigations made at the Bureau, and consisted in testing the mechanical strength of joints; measuring the resistance between adjacent lengths of pipes connected by such joints; determining the corrosion around such joints when a given difference of potential is maintained between adjacent lengths of

pipes, or a given voltage applied to a line containing many such joints; finding the amount by which the current is reduced when such joints are used as compared with the same pipe in the same soil with lead joints, and making field studies where cement joints and other kinds of insulating joints are used, including the methods of making joints in practice.

I cannot discuss the subject further than to say that we have found insulating joints of very great value in reducing the current in pipe lines, and so reducing the corrosion caused by such current. Where the potential gradients are high, the joints must of course not be placed too far apart, as in that case the potential difference at each joint would be sufficient to cause considerable joint electrolysis. There is still some difference of opinion among engineers as to the practical value of insulating joints, but our experience is that, while they should not be depended upon as the sole means of protection to pipes, they are economically and mechanically practicable, and are a very important auxiliary means of protection, particularly in the case of gas pipes. They are less often used in water-pipe lines.

Methods of Making Electrolysis Surveys.

Another subject to which we have given much attention, and which will shortly be discussed in one of our Bureau publications, is the methods of making electrolysis surveys. One of the objects of such surveys is to determine the over-all potential differences between different parts of a city, due usually to the street railway system where a grounded return is used, as in the overhead single-trolley system. When the negative bus bars of the power supply stations and substations are grounded, and negative cables are run out to the grounded tracks, there is established a region of low potential around the station, and large potential differences are often produced in the systems of gas and water pipes, lead cable sheaths, reinforced concrete, and any other conducting structures embedded in the earth. In consequence, electric currents of considerable magnitude flow through the earth from tracks to pipes at points more or less distant from the stations, and from pipes back to tracks or negative cables in the region

near the power stations. It is in the regions near these stations, where currents — sometimes of hundreds of amperes — are leaving the pipes and cables, that electrolysis is most severe. It is the purpose of these surveys, therefore, to determine not only the over-all potential differences, but also the differences of potentials between tracks and pipes, the current density and potential gradients in the rails of the tracks, whether the tracks are well bonded, and the location of defective joints, the approximate current flowing in the pipes wherever that can be conveniently done, — and especially where the damage from the electrolysis is most serious. The engineers of the Bureau have acquired considerable experience in such work. They employ methods which can be used by any engineer.

Methods of Electrolysis Mitigation.

TRACK DRAINAGE AND PIPE DRAINAGE.

Having made an electrolysis survey in any given place, and learned the condition of the railway and pipe systems, the next question usually is how to remedy the trouble. As already indicated, we do not believe it practicable to insulate the pipe systems from the earth, nor to prevent serious corrosion to the pipes if heavy electric currents are allowed to flow into and out of them again. There remains, therefore, two possibilities. First, to bring the current back to the stations by metallic conductors provided for the purpose in such a way as to keep the current out of the pipes almost entirely; or, second, to allow the current to get into the pipes and cable sheaths but provide metallic conductors for getting it out again without serious corrosion to the pipes. In other words, drain the current out of the tracks by insulated negative cables, keeping the tracks as nearly at the normal earth potential as possible, and insulate the negative bus bars at the stations, so they may be kept at any desired potential difference below the earth; or, drain the current out of the pipes by means of copper cables tapped into the pipes, the bus bars being grounded. These two systems may be briefly designated as the "Track-Drainage System" and the "Pipe-Drainage System," respectively.

No one will question that the first of these methods is to be preferred, if it can be carried out economically. By it we correct the evil at its source, and it is undoubtedly simpler in theory and on many accounts better in practice. It has, however, been thought by many to be prohibitive in cost, and has been very little used in American cities. The pipe-drainage system, on the contrary, has been strongly advocated, and, in one form or another, much used. The investigations of the Bureau of Standards, however, which have been extended over several years, and have included a considerable number of large and small cities, have convinced us that the pipe drainage system as a principal method of protection is not only complicated and expensive to install and maintain, but is in the long run not an adequate remedy for electrolysis troubles. On the other hand, the track-drainage system when properly designed and installed we find to be simpler and more effective and far less expensive than has been supposed.

The difference between the track-drainage system, with insulated negative feeders, and the ordinary method of reinforcing the conductance of the rails by means of bare copper wires, is very fundamental. In the latter, the copper and tracks must have a potential gradient sufficient to cause the current to flow back to the station, and if this is to be small enough to obviate electrolysis troubles (say 0.3 or 0.4 volt per 1 000 ft. as a twenty-four-hour average, equivalent to about 1 volt per 1 000 ft. at peak load), the joint conductance of track and copper cables must be very high; that is, a very large quantity of copper must be used, and this generally makes the cost prohibitive. On the other hand, if the negative cables and negative bus are insulated (except at the end connected to the track), the drop of potential over the cables can be such as to give maximum economy. That is, the quantity of copper can be so adjusted that the loss of power per annum in the negative return and the annual charges on the cables shall be approximately equal; in other words, the sum of the loss of power in the negative return per annum and the annual charges on the negative cables may be a minimum. This may require a drop three or four times as much on the insulated cables as would be permissible on the tracks, and the negative bus bar may be 10 or 20 volts, or whatever is necessary, below earth potentials.

Resistance taps would be inserted in the shorter cables, so that the drop in potential in the various feeders shall be nearly equal. For the sake of economy it is usual to have a smaller drop in the shorter feeders than in the longer, and so have a potential gradient on the tracks toward the power house. But this should be kept small, so as to keep down the tendency for the current to leave the tracks and return by way of the pipes.

If this were a gathering of electric-railway engineers, I should like to describe more in detail the results the Bureau of Standards has obtained in applying insulated negative feeders to electric-railway systems for the purpose of reducing electrolysis troubles. Our work has included both large and small systems, urban and interurban, and the results obtained as to economies that accompany and more or less offset the cost of electrolysis mitigation have sometimes surprised railway officials.

So far, I have said but little concerning the pipe-drainage system which has been used in this country more than any other system. Connecting the pipes in the positive areas to the tracks by heavy cables lessens the damage, but it greatly increases the current in the pipes; and this is a serious objection. Where insulating joints are in use, and wherever defective joints occur, it tends to increase the joint electrolysis. In repairing gas pipes it is necessary to put a jumper cable around a proposed break in the pipe in order to avoid the possibility of causing an explosion by the spark or arc when the current in the pipe, which may be heavy, is broken. Such drainage cables tend to lower the potential of the pipes drained, and so attracts current to them from other pipes and cables, thereby making them a source of danger to all other pipes not drained. To completely drain all the pipes in the complex network of a city is almost impossible, and to keep track of the changes in the railway system, and readjust these drainage cables when necessary, would be an immense undertaking. The system has rarely been carried into effect on a large scale, but has been used to a greater or less degree in many places. We have reason to believe that in many places where pipe drainage has been practiced serious damage from electrolysis is becoming evident.

Surveys Made by the Bureau of Standards.

The Bureau of Standards has made electrolysis surveys for St. Louis, Springfield, Ohio, and Springfield, Mass., and several other places, and has found in a number of cases that the economies of power effected in connection with the improvement in the roadway, the shortening of feeding distances, and provision of a proper return for the current, has been sufficient to yield a fair income on the cost of the changes and new construction. In St. Louis, the United Railways Company equipped a new station in accordance with plans worked out by the Bureau of Standards, and found that the results attained with respect to cost and electrolysis protection were in accordance with the advance calculations made by the Bureau. The Ann Avenue station afforded an excellent opportunity to test the theory of the insulated return system and make a comparison with the pipe-drainage system. In this station the negative cables were used insulated with the negative bus bar insulated from earth, and readings were taken on the potential drops and also on the current in 21 gas and water pipes. Then the bus bar was grounded and the cables used as though they were bare copper, and again the potential differences were measured, as well as the current in the pipes. It was found that with the insulated feeders the total current in the pipes was 65 amperes, whereas with the cables uninsulated and so a steeper slope of potential in the earth, the total was 273 amperes, more than four times as much.

While no attempt was made in this investigation to install a complete pipe-drainage system, some of the pipes near the station were temporarily tied to the tracks in order to determine the effect of so doing on the current in the pipes.

The current in the 21 pipes was increased by so doing from 65 to 85 amperes when the negative cables were insulated. When they were uninsulated, the current was increased by tying in the pipes from 273 to 844 amperes. Thus it is seen that with pipe-drainage the current is ten times as great in the pipes when the negative feeders are uninsulated as when they are insulated. These measurements show what is to be expected, — that the

current flow in pipes is greatly augmented when the pipes are connected to the tracks or bus bar near the station.

Measurements of differences of potentials between pipes and rails also show the great advantage of the insulated feeder system. The full result obtained on this experimental installation has been published in technological paper No. 32.

In Springfield, Ohio, an insulated negative feeder system was installed at the expense of the railway companies in accordance with the recommendations of the Bureau, and measurements were then made to determine the degree of improvement effected in over-all potential differences in the earth, and in the differences between rails and pipes. A joint report on the system and its results, addressed to the city manager of Springfield, was prepared by representatives of the Bureau of Standards and representatives of the gas, water, and telephone companies and the railway companies. The report recommended that the system of insulated negative feeders installed by the railway companies be continued and maintained and that a system of pressure wires be installed to facilitate measuring potential differences between each station and various points at a distance therefrom. That the railway companies agreed to this report voluntarily shows that they were satisfied that the system installed was to their interest as well as to the interest of the pipe-owning companies. The American Railways Company with commendable progressiveness is adopting this system on other railways under their management.

The Bureau of Standards has been coöperating with the city of Chicago and the Board of Supervising Engineers in charge of the surface railways of Chicago, and we hope to see one station fully equipped shortly as a demonstration of what can be done at a moderate expense toward mitigating the damage due to electrolysis in Chicago.

The city of Springfield, Mass., and the various utility companies affected recently asked the Bureau to make a complete electrolysis survey of that city and render a report as to the best methods of improving conditions with respect to electrolysis. This work was done in June, but the final report has not yet been completed, owing to other urgent work.

Coöperation between Pipe-Owning Companies and Railway Companies.*

One of the most important reasons why electrolysis conditions have not been remedied oftener by the railway companies is that the engineers of the railways and of the gas and water companies have not got together to study the question.

As an illustration of what can be done by coöperation, I may cite a recent experience of our own. A water company in California employed an engineer to make an electrolysis survey of its system and prepare a case against one of the street railway companies of that city, since the company refused to remedy conditions. The case was to be taken before the California State Railway Commission, and the Bureau of Standards was asked to send one of its engineers to look over the matter and see if the claims and proposals made by the water company were reasonable. The Bureau complied with the request with the understanding that our engineer was not serving the water company merely, but would be impartial as between the railway and water companies. When he had examined the case he saw that the system which the State Commission was to be asked to order the railway company to install was not the most economical possible, and that since two different railway companies were involved, it would be better to consider the whole problem at once, instead of trying to make a case against one at a time. He then proposed to these two railway companies that, instead of fighting the water company before the State Commission, they unite with the water company and the

**The Joint Electrolysis Committee.* In order to get some reliable engineering results as to current practice in this country and abroad, and as to results achieved by different methods, a joint electrolysis committee was established about six months ago, at the instance of members of the American Institute of Electrical Engineers. This committee has three members each of the American Institute of Electrical Engineers, American Gas Institute, Natural Gas Association, American Electrical Railway Association, American Railway Association, the American Telephone and Telegraph Company, and one member from the Bureau of Standards. The chairman is Mr. B. J. Arnold, of Chicago, past president of the Institute of Electrical Engineers, and the committee contains many men prominent as railway, gas, and electrical engineers. There can be no doubt that the committee will gather valuable engineering data, and do a good service in getting together representatives of the various interests concerned and having them study electrolysis mitigation as an engineering question. The committee agreed at the start that legal considerations and all questions of responsibility for damage should be excluded, and attention given to the scientific and engineering phases and to determining what had been accomplished in different countries. It is to be regretted that there are no representatives of the water-works associations on this committee.

representative of the Bureau of Standards in studying the problem, and finding in what manner and at what cost the railways could take care of their return current so as to eliminate further damage to the water pipes. When the railway companies saw that it was a clean proposition for an engineering study, not committing them in advance to the results obtained, they accepted the invitation, and after a most thorough and detailed study, including the cost of construction and increased operating costs, as well as economies effected, the four engineers (one representative each of the two railway companies, the water company, and the Bureau) agreed on the plan to be recommended, with the intention of asking the State Commission to order its installation, instead of making a fight before the Commission which the latter would have to decide.

In another case, a city asked the Bureau to recommend a form of enforceable ordinance which the city could pass that would compel the electric railway company to take care of its current so as to stop the damage to the city's water pipes. The Bureau advised the city that before passing an ordinance an engineering investigation should be made to determine exactly what should be done to remedy electrolysis conditions and ascertain what it would cost. Such an investigation was made and a report submitted by the Bureau to the city and to the utility companies concerned. The investigation showed that the trouble could be corrected by the installation of a moderate quantity of insulated negative copper, building one new substation and enlarging another. The cost was quite appreciable, but the saving in power thereby effected was large enough to cover the extra operating expense, the interest and depreciation on that part of the new construction not otherwise needed and leave a small profit, the correction of serious electrolysis trouble being accomplished without any real net expense, and the service on the railway as regards car speeds and car lighting being improved. The railway company was entirely satisfied with the report, including the estimates of cost of new construction and operation and savings of power and improvement of service, and indicated their intention to carry out the work promptly. I am sorry to say, however, that to date nothing has been done, although several months have

elapsed. The relation between electrolysis mitigation and improved electric-car service just alluded to is a matter of much importance.

Different Conditions Require Different Treatment.

Enough has been said to show that conditions with respect to electrolysis are very different in different places. Precautions that are sufficient in one place are insufficient in another; and changes or new construction that can easily be afforded by one company might be a hardship to another. Hence a uniform requirement on all railway companies, passed by a state legislature or by city councils, is not to be encouraged. On the other hand, a general statute or ordinance holding railway companies responsible for the destructive effects of their return electric currents and requiring them to take suitable precautions to minimize such effects would be reasonable. If the managers of utility companies will treat the question in an enlightened and progressive manner as an engineering and business proposition, and keep out of the courts as completely as possible, city councils and state legislatures will no doubt be patient and give them a chance to solve the problem in an economical and engineering manner. But if these managers assume a reactionary attitude and decline to do anything until forced to do so, they may be compelled to do in many cases far more than is necessary or reasonable.

How the Bureau's Work is Done.

In this work the Bureau of Standards is not acting as consulting engineers, to serve a single company or interest as against other companies or interests. On the contrary, the work is being done as a part of our general electrolysis investigation, and many of the results obtained are published for the benefit of cities, utility companies, consulting engineers, and all others interested. The records and information obtained by the Bureau are available to any one who visits the Bureau even before publication, and we have frequent calls from consulting and company engineers interested in these questions. If, as we expect, the practicability and advantage of the insulated negative feeder system is soon

completely demonstrated, it will not be long before its use will become more or less general and the Bureau of Standards will be able to turn its attention to other subjects. But so long as the practicability of this system is not generally admitted, and nothing better is devised in its place, and electrolysis conditions continue to get worse every year, as they are now doing in most places where the overhead trolley system is in operation, we expect to continue our work of investigation and education.

At the beginning, the Bureau bore the greater portion of the expense incurred in its surveys and reports, and utility companies that coöperated with the Bureau generally did so as a favor to us, which we fully appreciated. Now that the practical value of the results achieved are better understood, the expense is borne in larger proportion by the utility companies concerned, but in every case the Bureau acts as an impartial agency, just as mindful of the interests of the railways as of the pipe and cable owning companies.

Conclusion.

One peculiar feature of the electrolysis problem is that so many different interests are affected. The gas, water, telephone, electric light, telegraph, and signaling companies — and often many private owners — have pipes or cables affected by the electric current from the street railways. Heretofore the railways have generally claimed — and usually I think sincerely — that it was beyond their power to prevent the damage, and hence they could not be held responsible for it, — at least to the degree that they could if it was practicable to prevent it. Naturally the railways have favored the use of pipe coverings and pipe drainage as a means of reducing the damage that put much of the responsibility on the pipe-owning companies. The cable-owning companies have spent large sums of money in protecting their cables by drainage. This is more practicable for cables than for pipes, for the sheaths are usually continuous electrically; but it is far more difficult and more expensive when the potential gradient is large than when it is small. If the use of uninsulated negative feeders were the only method available for taking care of the return current, the railway companies could be excused for not

maintaining a low-potential gradient in the earth. But the use of insulated feeders is so much more economical that, generally speaking, there is no longer any excuse for permitting bad conditions. Just as soon as it is recognized to be practicable it will be deemed as necessary to spend money for negative conductors as for the positive feeders.

The method has been much used in Europe and to some extent in this country, but so little in this country that few engineers knew that it was used, and until very recently there were relatively few who believed it practicable. I know of no published account giving full particulars of the actual results obtained by such a system previous to the recent articles describing the work done by the Bureau of Standards.

I have laid a good deal of emphasis on the duty of the railway companies to take care of their return current, and of the need of applying the same kind of engineering talent and experience to this phase of plant construction and operation as to other phases. I wish also to emphasize the duty of the owners and managers of water works to coöperate with the gas and telephone companies and railways in studying the problem of electrolysis mitigation in an open-minded and progressive manner. Taking the matter into the courts is to be deplored. It is better to employ engineers to work together to solve the problem in a thorough and efficient manner than to employ experts to testify in court as to who is responsible or what are the damages. As the damage is cumulative from year to year, and the rate increases as the traffic increases, there will be no better time than the present to take up the matter.

DISCUSSION.

Mr. Robert S. Weston. I would like to ask Dr. Rosa to what extent internal electrolysis takes place from external influences, — that is, to what extent hydrates of the metals are produced in the stream of water within the pipe by external electrolysis.

Dr. Rosa. So far as I know, it is very unusual.

Mr. Weston. There have been instances where lead-poison-

ing cases have been alleged to be due to the action of the external electric current on lead service pipes affecting the action of the water on the lead, and it would be interesting to know whether you have ever had any cases of that kind in your experience.

DR. ROSA. I don't know of any such. So far as the electric current is concerned, electrolysis is only produced either when the current is going to the pipe or leaving it, and that would be on the outer surface, so there couldn't be any effect of that kind due to current from an internal source.

MR. WILLIAM C. LOUNSBURY. What effect does moisture have?

DR. ROSA. Moisture has a very great effect. If the soil is very dry the resistance would be very high, and as the moisture increases, the resistance decreases up to saturation of the soil. In addition to the varying amount of moisture, there may be varying amounts of soluble salts in the soil, and that would tend to make the resistance vary. If the soil is sandy and contains a considerable amount of quartz and mica, as is sometimes the case, the resistance is very high. That is one reason why the average resistance in Philadelphia is so high, because there is so much of that sort of dry and sandy soil containing quantities of mica. In some streets, also, there is more or less organic material which has seeped down from the surface into the soil, and that tends to reduce the resistance; but the soluble salts and water are the two principal things which reduce resistance.

MR. FRANCIS T. KEMBLE. I would like to ask Dr. Rosa if he has ever found pipes corroded or injured by reason of electric light wires being grounded on service lines.

DR. ROSA. I am very glad to be asked that question, because it is one on which I have very decided opinions. The grounding of the secondary circuits of transformers is one of the most important safety measures of protection to the general public and the users of electric light. If the insulation between the primary and secondary breaks down from a lightning stroke, or from deterioration with age, or from possible defect in manufacture, it will bring a high voltage (2 200 volts perhaps, and sometimes more) into the house, and that is of course very dangerous. Therefore in the interest of safety to the users of electric light — and that includes a very large portion of the public — it is im-

portant that the middle point of the secondaries be grounded, so if it does break down the current can flow to the earth and, without the secondary wire being brought to a high potential, the fuse will blow and disconnect the house wiring from the line wires. The connection to the earth must be a very good connection, or it is of no value. To run a wire into dry earth is of no value, either in case of lightning rods or of transformers. The practical question is, therefore, how to get a good connection to the earth.

Some companies drive a good-sized pipe several feet into the earth, and with a solution of salt surrounding the pipe, they endeavor to make a good connection. But it is very difficult and very expensive to make a ground of that kind that will have a low enough resistance to be satisfactory and safe. To ground all the transformers in a system by such means, and do a thorough job so as to really protect the public, would be so expensive that I think the lighting companies would fairly claim that it was prohibitive. Many of them are grounding them by means of driven pipes, but I don't know of a case where the ground other than on the water systems is really satisfactory. When they connect to a water pipe there is no current flowing to the ground, and there is absolutely no electrolysis produced except when a lightning discharge or accident happens, and then it will usually be for a few seconds only. Therefore there wouldn't be as much damage to the water system in a hundred years as there would be in one day by the street railway currents frequently found to be flowing through a pipe system.

Therefore I hope that the water companies generally, after satisfying themselves of the truth of what I am saying, will consent to this practice and encourage the lighting companies to ground their transformers on the water system. The reason why the water pipes are better than an ordinary pipe driven in the ground is that the water pipes are generally connected metallically together, and so form an extended system in good contact with the earth, furnishing all together a good connection for the electric current to go through. To get so good a ground that the resistance is only one ohm requires a very large surface of pipe, and I don't know of any way that is really practicable and satis-

factory to ground these transformers except by connecting them to water pipes.

MR. KEMBLE. They get the best ground in that way, and we are not hurt.

DR. ROSA. And the electric companies will no doubt consent to pay for any damage that is produced, if any can be shown to be produced.

MR. CHARLES W. SHERMAN. If I may ask one other question along the same line, I should like to know whether Dr. Rosa considers the practice of grounding the secondary of the transformer to the main pipe preferable to that of grounding the several house services upon the service pipes in the houses, which is, I think, the more common custom in this vicinity.

DR. ROSA. Both should usually be done, although in some cases when transformers are near the house, one ground would be sufficient.

THE PRESIDENT. I should like to ask Dr. Rosa if he sees objection to the practice of grounding secondary wires to house services in a district where the potential is strongly plus; in other words, would there be greater objection to this practice where the tendency of the current is to flow from the pipes than in a negative district where the tendency is otherwise.

DR. ROSA. I don't think it will make a particle of difference. In regard to pipe grounds, of course it is very commendable in a company for it to go to the trouble and expense of securing a good ground without connecting with the pipes. We have been trying to get the results of actual experience, and if there is anybody who can give us actual results of measurements we should be glad to receive them. We have been making such measurements lately, and have spent considerable time in making the actual measurements of ground resistance of these outside pipes and plates which are used not only for electric transformers and circuits, but also for lightning conductors. In Washington they use this system of driving pipes outside, and they have spent a good deal of money and tried very earnestly to make a good connection. We sent one of our engineers out with an engineer from the company, not long since, to make measurements. He was confident that their grounds would show a very low resistance,

and he was surprised to see how high they were. That is, the resistance was not nearly as small as he thought it would be. We are extremely anxious to get actual measurements, and, if it can be shown that any company is doing this in a way to get good results, we will be the first to acknowledge it and to advertise it. What we are after is information, but we have not yet got enough to say that that is being done in a way which will give first-class protection. Merely to get a fair ground so that the current will flow to the earth is not enough. They sometimes get a thousand volts difference in potential in the case of a breakdown and it would be dangerous before the current ceased to flow.

MR. FRANK E. MERRILL. Some years ago I presented a paper* on our experience in Somerville in regard to the grounding of the secondary wires of electric-light companies to water pipes. After a very careful investigation of the matter, and after having called in some electrical experts, we came to the conclusion that there was no harm to be done to the water pipes, and we granted permits to the electric company to attach their wires. I will add that our experience since that time has not given us reason to feel that we arrived at a wrong conclusion, for we have never had any trouble from that source.

MR. MORRIS KNOWLES. Two things have suggested themselves to me. The doctor referred to the investigation of interurban systems as well as local systems. In regard to the former, many use the alternating current, and the first question which suggests itself is, — Has there been any difference found in the effect of alternating current and direct current?

The second question is suggested by his reference to the fact that reinforced concrete deteriorates when attacked by electrolytic action. I understand in one place where a large pipe had several holes and weak places, due to rusting through, that a reinforced concrete jacket was placed around the pipe. Now, are we to understand that probably that reinforced jacket itself will disintegrate and therefore the condition in the pipe line become as bad as ever?

DR. ROSA. As to the question about the alternating current, it is true that the electrolytic damage due to the alternating

*JOURNAL N. E. W. W. A., *23*, 180 (1909).

current is very much less than that due to the direct current. We have been making some experiments on that subject, but have not yet completed them and have not published any results. We can say positively, however, that the effect is very different indeed. Also, when direct currents are used, if the current reverses frequently, as it does as the traffic varies, the damage is less than when it is all flowing in one direction. That is to say, by the use of insulated feeders the current at certain regions in the tracks frequently reverses as the traffic changes. Sometimes it will be flowing away from the pipe, and a little later it will be flowing towards it, and that produces very appreciably less corrosion than if it is always flowing in one direction, provided the reversals are rather frequent.

As to the question of coating a pipe with concrete, — there are perhaps two questions in that. The concrete itself, buried in the earth, may be damp and a pretty good conductor of electricity. It is not, therefore, protecting the pipe from electrolytic damage. If the current flows along the pipe and out through the concrete to the earth, it will produce corrosion, although the concrete will preserve the iron from corrosion from the outside. If there is iron buried in concrete for reinforcing, if considerable current flows through it there may be corrosion of that iron. If the iron is so placed that the current flows into and from it so that the iron is an anode it will become corroded and at times it may break off the concrete around it; if it does not do that it may still become corroded enough to be weakened. If the current flows toward the iron from the concrete it may soften the concrete. If the current density is great, as it may be in exceptional cases, the damage may be severe, but generally it is not.

Mr. William F. Sullivan. I should like to ask what effect these currents have upon steel structures, such as viaducts and elevated structures. Does the electrolytic action go on in the overhead structures?

Dr. Rosa. In the case of overhead structures resting upon the earth, — columns, for example, resting upon a concrete foundation, — if the current is flowing down a column from an overhead railway it may produce rather serious corrosion. In New York City it was sufficiently serious so that the company spent half

a million dollars or more to insulate their structures, and at the present time the elevated railways in New York are not grounded to the structure as they formerly were, and the corrosion at the base of the columns was stopped by that means. There may be in some cases serious corrosion of that kind.

MR. J. M. DIVEN. Track and pipe drainage is only a makeshift. The only absolute safety is to keep the current out of the ground. It can be done, and, being practicable, it should be required, even if it costs the electric railway companies more. In the long run it might prove cheaper for them than paying for damages to water mains and other underground structures.

MR. TANNATT. I would like to ask the last speaker to go a little further and tell us how he would keep the current out of the ground.

MR. J. M. DIVEN. By a complete metallic circuit, or, in other words, double trolley. Railroads with the double overhead trolley are in operation, and have been for a number of years, in Cincinnati, Ohio, and Washington, D. C. The New York underground trolleys all form a complete metallic circuit, so that no stray currents are found in the ground, except such as stray over from Brooklyn.

METERING AN OLD CITY.

BY JAMES A. MC MURRAY, ENGINEER IN CHARGE INCOME BRANCH WATER SERVICE, BOSTON, MASS.

[*Read September 10, 1914.*]

Every city and town should furnish its inhabitants with an abundance of good water, to promote their health and prosperity and protect their property from fire; and every one should help to conserve the supply by preventing its waste. To provide an adequate supply for a large city, an enormous outlay of money is necessary, and, of course, the burden must be borne by those who receive the benefits.

The Boston water supply, which cost $27 000 000, was being rapidly exhausted when the Massachusetts legislature of 1895, exercising sound judgment, created the Metropolitan Water Board to conserve the sources of supply in the state and to furnish water to the cities and towns in the newly-created Metropolitan Water District. The city of Boston made remarkable progress in reducing waste with the Deacon meter system and a corps of waste inspectors. The Deacon meter system will discover the leaks, but without intelligent and faithful work on the part of the inspectors the waste cannot be permanently reduced. This system had been practically abandoned before the general installation of meters, as was evidenced by the high consumption in the city of Boston.

The Metropolitan Board, which acquired Boston's sources of supply, has expended up to the present time about $42 000 000 in constructing the present system, and to meet this obligation the state levies an annual assessment of $2 300 000 upon the cities and towns of the metropolitan district. Boston's annual share is about $1 800 000, or 78 per cent. of the total. Various methods of levying the assessment were used; at the present time it is based upon the consumption and valuation — two thirds on consumption and one third on valuation. The present metro-

politan supply was deemed sufficient for all purposes, including increase in population and business, until 1930; but the ever-increasing consumption caused the Metropolitan Board to make an investigation to determine the cause of the unwarranted increase. This survey was made in 1903 and 1904. It was found that the consumption of 1903, 119 gal. per day per capita, should not have been reached until 1920. This condition could not be allowed to continue if the supply were to hold out.

In 1903 the state commenced to meter the mains supplying the cities and towns in the district to determine the consumption in the several cities and towns. This attempt to place the responsibility for the increase, and the coöperation of the local departments with the Metropolitan Water Board to reduce the consumption, accomplished some good results; but, despite every effort, the consumption continued to increase until it became apparent to all concerned that one of two things must be done: either an additional source of supply, involving the expenditure of a vast sum of money, must be procured at once,— and any outlay of money for this purpose would be an unwarranted waste of public funds,— or the waste must be stopped.

It was decided to stop the waste, and it was further agreed that the only sure way to stop it and reduce permanently the high consumption was to place the responsibility upon the individual, and meter every service pipe. To this end, the Massachusetts legislature of 1907 passed the following statute, which went into effect January 1, 1908:

AN ACT TO PREVENT WASTE OF WATER IN CITIES AND TOWNS SUPPLIED FROM THE SOURCES OR WORKS OF THE METROPOLITAN WATER DISTRICT.

Be it enacted, etc., as follows:

Section 1. All cities, towns, districts or corporations which derive all or any part of their water supply from the metropolitan water works or from sources used by or under the control of the metropolitan water district shall after December thirty-first, nineteen hundred and seven, equip with water meters all water services thereafter installed for them and shall also annually equip with meters five per cent. of the water services which were unmetered on December thirty-first, nineteen hundred and seven; and shall also thereafter charge each consumer in proportion to

the amount of water used: provided, that no city, town or district shall, in any one year, contract for more than the number of meters to be installed by it during that year under the provisions of this act; and provided, also, that a minimum rate may be fixed for which the consumer shall be entitled to a stated quantity of water.

Sect. 2. The provisions of this act shall not apply to the water service for fire purposes only of any city, town, fire district or individual, nor shall such service be taken into consideration in computing metered water service. All water used for the supply of public buildings or other premises under the control of a city, town or district, and all water used from the public works for the flushing of sewers, watering of streets and all other purposes, except for the extinguishment of fires, may be paid for by the city, town or district.

Sect. 3. Meters shall receive the necessary care and maintenance to secure proper efficiency and shall be tested or replaced by the city, town, district or water company whenever there is reason to believe that the records furnished by them are inaccurate, or whenever the service furnished is in other respects inefficient. Cities, towns, districts and corporations may make rules and regulations relative to the care, maintenance and protection of meters, and for properly ascertaining and recording the amount of water actually used during specified periods by each water consumer. Proceedings for the enforcement of this act shall be instituted and prosecuted by the attorney-general upon complaint of any party in interest.

Sect. 4. This act shall take effect upon its passage.

Approved June 15, 1907.

This act was amended in 1909 to provide a penalty for failure to comply with its requirements, as follows:

AN ACT RELATIVE TO THE USE AND CARE OF WATER METERS IN THE CITIES AND TOWNS OF THE METROPOLITAN WATER DISTRICT.

(Chapter 177.)

Be it enacted, etc., as follows:

Section 1. Section three of Chapter five hundred and twenty-four of the acts of the year nineteen hundred and seven is hereby amended by striking out the last sentence and inserting in place thereof the following: It shall be the duty of the metropolitan water and sewerage board to supervise and promote the enforce-

ment of the provisions of this act, and if any city, town, district or corporation violates or neglects in any respect to comply with the provisions hereof, said board shall forthwith give written notice of such violation or neglect, together with the facts relative thereto, to the attorney-general for his action in the premises. The supreme judicial court shall have jurisdiction, upon an information in equity filed by the attorney-general, to enforce all the terms and provisions of this act, — so as to read as follows: — Section 3. Meters shall receive the necessary care and maintenance to secure proper efficiency and shall be tested or replaced by the city, town, district or water company whenever there is reason to believe that the records furnished by them are inaccurate, or whenever the service furnished is in other respects inefficient. Cities, towns, districts and corporations may make rules and regulations relative to the care, maintenance and protection of meters, and for properly ascertaining and recording the amount of water actually used during a specified period by each water consumer. It shall be the duty of the metropolitan water and sewerage board to supervise and promote the enforcement of the provisions of this act, and if any city, town, district or corporation violates or neglects in any respect to comply with the provisions hereof, said board shall forthwith give written notice of such violation or neglect, together with the facts relative thereto, to the attorney-general for his action in the premises. The supreme judicial court shall have jurisdiction, upon an information in equity filed by the attorney-general, to enforce all the terms and provisions of this act.

Sect. 2. Said chapter five hundred and twenty-four is hereby further amended by striking out section four and inserting in place thereof the following: — Section 4. If a city, town, district or corporation in any year neglects or refuses to comply with the provisions of section one, it shall forfeit to the commonwealth for the use of the metropolitan water district not less than twenty dollars and not more than one hundred dollars for each day after the expiration of said year during which such violation or neglect continues. The penalties or forfeitures which may be incurred hereunder may be recovered in an action of contract brought in the county of Suffolk in the name of the commonwealth, or may be recovered by an information in equity in the name of the attorney-general at the relation of the metropolitan water and sewerage board, brought in the supreme judicial court for the county of Suffolk.

Sect. 3. Section one of this act shall take effect upon its passage, and section two shall take effect on the first day of January, nineteen hundred and ten.

Approved March 18, 1909.

At the beginning of 1908, when the meter law went into effect, there were in the city of Boston about 95 000 service pipes, 5 000 metered and 90 000 unmetered. It had been the practice of the department to meter railroads, wharves, large business buildings, hotels, and large apartment houses; in fact, practically every business building has been metered for a number of years. But no attempt had been made to meter premises where water was being wasted continuously and carelessly.

Now that the city was compelled to meter all premises, it was a question how to proceed in order that the waste of water might be restricted and the income not too heavily reduced. Of course there were no positive data as to the amount of water the different classes of houses would use, and there was no way of telling how much money would be derived after the meters were installed — in a word, whether the meters would increase or decrease the revenue.

It was decided, finally, to meter the large tenement houses and buildings with saloons, because it was presumed that great waste would be found in them. In many instances this was found to be true, though very often great waste was found in small houses.

During the year 1908 only a few meters were set, although under the act about 4 500 old service pipes and all new services should have been metered. In 1909, however, the department hastened to make up for lost time, because of the penalty which the legislature of 1909 added to the meter act for failure to comply with its requirements. A force of ten plumbers under the direction of a foreman was engaged in setting the meters. One or two plumbers were sent into each district to meter the buildings selected. Each plumber had a helper and a team with a driver; the team carried the men and the stock from house to house, the houses being very often widely separated. This method was used in 1909 and 1910. In 1909 6 584 meters were installed, and 6 615 in 1910.

In 1911, the Public Works Department was created, and under the direction of the Commissioner of Public Works the installation of meters by districts was begun. It was decided to send the larger part of the plumbing force into one district and meter every house. Each district was divided into sections and the

men were supplied with meters and fittings of all kinds from a portable storehouse; which was moved with the men from section to section. By this method the work was done more quickly and economically, and, furthermore, important data were obtained.

The first district metered was East Boston, where 5 000 meters were set in the year 1911. The water for this district is measured by two Venturi meters. In 1911 the consumption was 5 511 000 gal. per day, 95 gal. per capita; after the district was wholly metered the consumption fell to 3 586 200 gal. per day, 58 gal. per capita. The second district metered was Charlestown, where 4 000 meters were installed in 1912. The consumption in 1912 was 6 860 200 gal. per day, 168 gal. per capita; in 1913, when the district was all metered, the consumption dropped to 4 394 200 gal. per day, 107 gal. per capita.

The following table gives the daily and per capita consumption in Charlestown and East Boston from 1910 to 1913, showing the remarkable drop in consumption in both districts due to the installation of meters:

	Charlestown.		East Boston.	
Year.	Daily Consumption. Gal.	Per Capita. Gal.	Daily Consumption. Gal.	Per Capita. Gal.
1910....	7 552 700	187	6 172 600	110
1911....	7 528 000	185	5 511 000	95
1912*...	6 860 200	168	4 416 200	73
1913†...	4 394 200	107	3 586 200	58

The following is a statement of the daily consumption in East Boston and Charlestown, also of the daily and per capita consumption of water for domestic and for manufacturing and mercantile purposes in these districts in 1913.

		East Boston.		
Total Daily Consumption. Gal.	Per Capita.		Daily Consumption. (CityMeters.) Gal.	Per Capita. Gal.
		Domestic,	1 241 007	19.5
		Manufacturing and Mercantile,	1 344 431	21.5
3 586 400	58		2 585 438	41.0

* East Boston went under meter rates in 1912.

† Charlestown went under meter rates in 1913.

CHARLESTOWN.

Total Daily Consumption. Gal.	Per Capita.		Daily Consumption. (City Meters.) Gal.	Per Capita. Gal.
		Domestic,	885 291	21
		Manufacturing, and Mercantile,	2 118 164	50
4 394 200	107		3 003 455	71

It is interesting to observe that in East Boston the city receives income from 73 per cent. of all the water furnished the district, and 70 per cent. in Charlestown. It is also to be noted that the underground waste in East Boston amounts to 17 gal. per day per capita, and in Charlestown 36 gal. per capita. While great results have been accomplished in reducing inside waste, it is evident that outside waste must not be ignored.

In South Boston, 5 000 meters were installed last year, but the results will not be obtained until the end of the present year. At the present time, the North and South End districts of the city are being metered.

By metering every house in a district, the coöperation of the owners was secured and a campaign of education was started among themselves. Everybody wanted to know something about these dreadful machines. The department coöperated with the residents in every way. Before a district was placed under meter rates each meter was read at least twice, and if leaks were found on the premises the owners were notified in due season. If very bad leaks were found, for sometimes the waste was enormous, and the owner did not stop the leaks, an inspector was detailed to hunt him up and inform him of the waste and to advise him further that if the waste was not stopped immediately the water would be shut off. Circulars were distributed throughout the district, advising the people that meters had been installed in every house and that it was necessary to watch the fixtures in order that the water bills might be satisfactory, and special notices were printed in the local papers giving the same general information.

Much opposition was encountered when the district installation was begun, because of the many wild and extravagant statements of individuals in regard to the meter water bills. No attention had been paid by these dissatisfied individuals to the notices given them of the great waste on their premises. They

had become accustomed to ignore the notices of the waste inspectors, and, therefore, failed to heed the warning that the premises were under meter rates and that the leaky fixtures would cause large bills. When they received their first meter bill they had their first awakening as to the great quantity of water that was being wasted on their premises. Even after they had received their first meter bill many of these people failed to make the necessary repairs, and received a second and a third large bill. Finally they began to realize that if they were to get normal bills it would be necessary for them to keep their fixtures in order. In each district we met with the same general difficulties. Some people in each district refused to admit us or offered some plausible reason for not allowing the meter to be set inside; this was for the purpose of preventing the installation of the meter. But when they realized that every house must be metered they were glad to have the meter installed on the inside in order that they might read the meter and keep control of their consumption.

One of the greatest difficulties to overcome was where one service pipe supplied several houses which were built and owned by one man, but now owned by several individuals. To install one meter and render one bill would cause no end of trouble. Therefore the corporation counsel was appealed to, and he advised the department to lay a separate service pipe for each house and meter it, without cost to the owner. Then, again, in private ways two or more houses were supplied from one private main. In following the practice of the department to control underground leaks in private ways, we should install the meter at the head of the place. However, this would not do, as we would be unable to determine how much water each house had used. Again the advice of the corporation counsel was sought and he suggested that the department secure a right-of-way in these places and assume control over the pipe and services and to set a meter in each house. This was done to the satisfaction of the department, because in case of leaks the department now has the right to make repairs or replace the service pipe with a more suitable one.

Most frequently, and especially in the old houses, the service pipes run the length of the house to the rear under the floor and

the plumbing is very complicated. It requires the most careful examination to discover where the branches are located in order that the meter will measure all the water used in the house. Very often the branches are taken off close to the wall, and if a careful inspection is not made the meter may be apparently installed in the proper position and yet not cover important branches.

Very often we have found two and sometimes three service pipes in a dwelling-house. Of course, several service pipes are often found in a large building where formerly there were several smaller buildings. Wherever several service pipes are found we endeavor to eliminate all but one. Sometimes it is necessary to lay one large pipe and abandon the smaller ones. In this way we have but one meter to install and repair and to read, and but one account to open for the building. Generally the department does not abandon the surplus service pipes without the consent of the owner, although it has been done without his knowledge and without any inconvenience to the occupants of the building. The plumbers are expected to make a very careful preliminary inspection of the premises before installing a meter. Needless to say, however, sometimes their inspections are rather faulty and some of the fixtures are overlooked.

After a district has been metered, an inspection of each house is made by special inspectors, to make sure that every fixture is covered and also to see that every house has been metered.

Iron pipes, and we are finding a great many of them, are causing the department much trouble, because after a meter has been installed and the water turned on the owners complain that the supply is insufficient. Of course, it is true that in these cases the supply is very often greatly diminished; and to improve the supply the pipes must be cleaned as thoroughly as it is possible to clean iron pipes.

Many stopcocks had not been used for years until operated by our plumbers when setting the meters, and whenever an owner is obliged to use one and fails to find it in satisfactory condition the department is charged with poor workmanship. There was a wholesale attempt at one time to have the department install new stopcocks where the least defect was found in the old ones; but this, of course, the city refused to do because the department

had not damaged them. In many instances our plumbers noticed that the stopcocks were very defective, and instead of shutting the water off in the cellars went outside and shut the water off in the street. This did not prevent the owners from asking for new stopcocks; but when they were convinced that our men had not used the stopcocks in the cellars they withdrew their claims.

On January 1, 1914, the department had 41 168 meters in service, about 36 000 having been installed since 1909; 5 000 of these meters are set in outside boxes in the sidewalk. The meters are generally set in the cellar, either on shelves or in ground boxes, where the meters are protected by wooden boxes 14 in. deep with a light iron frame and cover. The meters set on the outside are 4 ft. from the surface in concrete boxes with iron frame and cover; these boxes are large enough to allow a man to enter and remove or change the meter without removing the box.

During the year 1912, about 900 meters were affected by the frost; about one fourth of these were eventually condemned as useless and the others, after repairs of one kind or another, were redeemed for service. In 1913 about 1 600 meters were affected by frost; some were but very slightly affected and others were removed when the pipes in the houses became badly frozen, even though the meters were not affected. In 1912 about 170 meters in outside boxes were affected, mostly in East Boston, where there are about 1 200 outside meters. In 1913 only 30 outside meters were affected.

The city has installed about twenty Detector meters, ranging from four inches to ten inches in size, on lines furnishing water for both fire and other purposes. No other type of meter would be allowed by the fire underwriters.

All meters are set by employees of the department. The only work done by contractors is the digging and backfilling, and the hauling and setting of boxes for outside meters. In addition to the work of repairing and testing meters which have been in service, the department tests every new meter before it is installed. During the past year 4 000 meters were changed, 600 discontinued, 11 000 tested, 4 000 repaired in the shop and 600 in service, and 7 400 meters were installed.

The following table gives the number of services, etc., and shows

the wonderful results obtained from meters in the past six years in Boston and the Metropolitan District.

Year.	City of Boston.						Metropolitan District.		
	No. Services.	No. Meters.	Percentage of Services Metered.	Population.	Daily Consumption. (Gal.)	Daily per Capita. Gal.	Population.	Daily Consumption. Gal.	Daily per Capita. Gal.
1908	94 960	5 380	5.7	643 810	98 379 300	153	973 320	125 441 000	129
1909	96 132	12 048	12.5	659 110	94 029 900	143	997 760	119 119 100	119
1910	93 780	18 467	19.7	674 400	87 346 700	130	1 022 230	112 092 100	110
1911	95 037	25 206	26.5	688 520	85 571 500	124	1 046 630	109 994 800	105
1912	99 700	34 565	34.8	718 900	90 037 500	125	1 086 690	116 230 700	107
1913	101 100	41 168	40.7	726 975	79 391 600	108	1 125 232	103 847 700	94

In the foregoing it will be observed that while the city is only 40.7 per cent. metered, the per capita has been reduced from 153 gal. per day in 1908 to 108 gal. in 1913.

Now, a word about the revenue from water. Without money the city could not maintain its large system, pay its large metropolitan assessments, and install and maintain meters. During the past year $3 031 600.36 were received, $2 051 523.76 from meter rates, $895 687.12 from annual rates, and $84 389.48 from service pipes, etc.; 200 000 bills were issued — 140 000 meter and 60 000 annual bills. When the city is entirely metered 100 000 bills quarterly will be issued.

A water bill is not a lien in Massachusetts on real estate, as taxes are, and therefore it is necessary for the city to follow the payments as closely as possible.

Many complaints are received about large bills. The causes are generally defective fixtures, underground leaks, carelessness, and cold weather. Underground leaks cause much annoyance to the city and the consumer. They are very difficult to find at times, and the city sends a special inspector to locate them as nearly as possible for the owner. When these leaks are repaired 50 per cent. of the excess consumption is allowed. This amount is allowed by all the departments in the country. In no other cases are abatements allowed, although during the past two

winters the commissioner has made small abatements on excessive bills caused by very cold weather, and his ground for so doing was because of the many buildings that are still unmetered in Boston and which still waste a great amount of water in the wintertime.

When meters were first introduced the public anticipated large bills and the city a large reduction in income. But, in conclusion, I think that all must agree that the water meters are accomplishing great results in Boston and the Metropolitan District, are giving satisfactory bills to the careful public, and providing, up to the present time, more than enough revenue for the needs of the department.

DISCUSSION.

MR. A. A. REIMER. This paper, I think, will lend force to our argument for meters in the older cities. There has been held up before us all the bugaboo of depleted revenue, that we would not get enough money to run the works with everything metered, and so on. But experience after experience during the last ten or fifteen years has shown that metering does not cut down the revenue to the danger point, at any rate. There may be some little decreases here and there, but the total decrease is not sufficient to be a dangerous one, and Boston's experience only parallels that of others that we have on our lists. I feel that this paper should be carefully studied by us all and we should put it down in our memories carefully, so that when we are faced with this argument it will be just one more weapon added to our list.

Our experience in East Orange has been exactly what you have here. In fact, we are making more money with the meters, although we are only about 35 per cent. metered, than we were with the old flat rates. Seventy per cent. of our people who were on the flat rates and now have in meters are saving money, and the city is squaring the account out of the other 30 per cent., and we are not a bit afraid for the future.

I am not at all conversant with the Massachusetts law. Evidently you are not quite as well fortified by your law here as we are by ours because of some of the features that Mr. McMurray has mentioned. I notice that your corporation counsel has

ruled that you would have to put in free services where there has been one service for several houses under different ownerships. We politely but firmly tell the owners to put in service pipes at their expense, and the law backs us up.

As to the question of piping underground in the basements of the houses, we are very arbitrary. We insist that the owner must have his piping taken out from underground, or we will pipe to a certain point and set the meter at that point, all piping ahead of the meter to be exposed. We do that for the sake of controlling the character of the material used from the main to the meter. We lay our services all the way from the main to the house line, and when we set a meter inside we want to know that the proper material is used, and have it exposed so when the inspectors go in they can see if there is a line of pipe between the foundation wall and the meter, and whether or not there has been any tap taken off. In that way we have been able absolutely to eliminate the illegal use of water by taps ahead of the meter.

THE PRESIDENT. I might say in regard to the decision of our corporation counsel that there is more equity in it, perhaps, than one not knowing all the conditions might think. In each case, so far as I recall, the pipe originally had been a private pipe, paid for by the owner or owners, and for many years, in some cases I recall in South Boston for thirty or forty years, we had been receiving revenue from something which cost us nothing at all. Knowing the conditions it seemed to me very reasonable, in equity as well as in law, that the corporation counsel should have decided as he did.

MR. FRANCIS T. KEMBLE. In New Rochelle we are metered practically throughout, and we don't have any trouble to speak of. It is a decided benefit to the small consumer, as against the flat rate. We insist on lead services from the main to the meter, and we own them from the main to the property line.

MR. MCMURRAY. Last year out of 36 000 meters in operation we found that 5 000 users paid the minimum rate.

In the city of Boston we have not yet reached that class of houses, but when we come to the south part of the city, to Roxbury, Brighton, and Dorchester, we will have a considerable number of that very class. There are a considerable number of

people in certain districts who are now clamoring for meters, and are willing to put them in at their own expnse, but of course we are endeavoring to place them where we think they will do us the most good, and we think that up to the present time our judgment has been correct.

THE USE OF OZONE AS A STERILIZING AGENT FOR WATER PURIFICATION.

BY S. T. POWELL, CHEMIST AND BACTERIOLOGIST FOR THE BALTIMORE COUNTY WATER AND ELECTRIC COMPANY.

[*Read November 11, 1914.*]

It would be superfluous to recite here the nature and production of ozone, as the subject has been discussed so often in technical journals within the last few years that the basic theory as to the electrolytic manufacture of this gas must be more or less familiar to all members of the engineering profession. So many problems, however, have been encountered in attempting to apply this method of water purification, and so many failures have been experienced, in this country at least, that a discussion of difficulties encountered in the method may prove of value.

It is a well-known fact ever since the time of Schönbein, and more especially since the careful studies of Tyndall, that ozone is one of the most powerful oxidizing agents known, and when a sufficient amount of the gas is brought into direct contact with certain organic substances, the combustion of these products is rapid. This property, of course, renders the gas a powerful bactericidal agent and one well suited for water purification, especially as it is harmless, as are the products of oxidation. In addition to the bacterial efficiency, ozone will materially reduce the color and organic suspended solids and remove certain odors that are at times present in many water supplies. Notwithstanding the many advantages attendant with ozone treatment for water, the systems installed have for one reason or another not been eminently successful. Many of the systems abroad have been efficient, but the cost of operation has been excessive; others have not only been costly to operate, but the results have been altogether unsatisfactory. The systems installed at Ann Arbor,[1] Mich., and Lindsay, Canada, are notable instances of this fact.

Before entering into a discussion of the causes of failure that

have been experienced, it may be well to give a brief résumé of the results of our experimental work and the conclusions that have been drawn from these tests. This experimental work covers a period of about five years, and was undertaken by the Baltimore County Water and Electric Company in perfecting its ozone plant. The laboratory work has been carried on by the writer under the supervision of Mr. A. E. Walden, chief engineer and superintendent.

This system was installed by the Water Improvement Company of Philadelphia for the purification of the Herring Run supply of the Baltimore County system. The ozone generators were similar to the well-known Bridge type, using, however, cylindrical aluminum electrodes and micanite dialectrics instead of the aluminum and micanite plates as originally designed. The mixture of ozone and water was effected by means of aspirators and mixing wells.

The system was inefficient, due partly to faulty generators, but mainly on account of the mixing device, as has also been proven by the inefficiency of the Ann Arbor plant, which was of the same general design. In redesigning the plant it became necessary to eliminate many of the original features and add others. The system as it exists at present maintains the same general type of generators, but these are cooled with artesian well water instead of by oil, and the unozonized air is cooled and dried by refrigeration before reaching the plant, which was not a feature of the original design. The greatest changes, however, that have been made were in the design of the aspirators and the mixing chambers so as to obtain a better mixture and a longer contact period of ozone and water. The operation of the entire system is much more flexible than formerly was possible, and the production of the gas is now easily regulated.

Although provision has been made for filtering the raw water previous to ozonizing, this has not been done excepting for short periods. For this reason the plant has been put to the test of treating a water containing a considerable amount of suspended matter, much of which is due to organic solids, principally algæ growths. Because of this condition we have been afforded an opportunity to study the effect and efficiency of ozone upon

highly colored water containing a material amount of organic suspended solids and high bacterial counts. The results of these studies have proven the efficacy of ozone for water purification when the gas is generated in sufficient quantities for the treatment of the water, and is thoroughly mixed and allowed to remain in contact with the water for a sufficient period of time.

COLOR REMOVAL.

Much has been written concerning the bleaching effect of ozone upon colored waters, and there are many data to prove that this treatment is exceptionally efficient in removing organic stains. There has, however, been considerable discrepancy in the percentage removal effected by different plants, some plants giving high color reductions and others showing practically none. These differences are due in part to the difference in efficiency of the separate systems, but mainly to the character of the coloring matter contained in the supplies.

The Herring Run ozonators showed no uniform color reduction from day to day with a fairly uniform ozone production and identical operating conditions. Experiments [2] undertaken to determine this phenomenon showed that with water colored by organic stain, as from decayed vegetable growths, the waters were easily bleached, but that ozone had no bleaching effect upon waters stained by chlorophyll and similar compounds that were present in the supply in a free state, due to the disintegration of algæ and similar micro-organisms. As would naturally be expected from these results, the percentage of color removal will be proportionate to these compounds that are present in a supply.

REMOVAL OF ODORS.

The controversy that has been carried on through the various journals by different investigators in reference to the ability of ozone to remove odors has lead to much research in an effort to determine the deodorizing value of this gas. Most of this experimental work has been carried on in reference to the removal of odors from the atmosphere, and little or no work has been undertaken in reference to the removal of odors from solutions.

In our tests here it was demonstrated that certain odors could be readily removed; others were removed with difficulty, or not at all. The odors arising from the presence of algæ and other micro-organisms were eliminated by ozonization only after the organisms were removed by filtration. If this was not done, the odors were intensified, owing to the disintegration of the plants, causing the odoriferous oils to be scattered through the water.

The removal of odors by ozone, either from water or from the air, depends upon the oxidation of the odoriferous substance and, therefore, must be considered from a quantitative standpoint, namely, that a given amount of O_3 will be required to oxidize a specific compound according to the oxidation reaction. Franklin[3] and J. C. Olsen[4] have both proven this in their experiments, and some of these tests have been confirmed by the writer in similar tests.

In attempting to remove odors from a water it should be determined if the substance causing the odor can be readily oxidized, and if so, the volume of O_3 that will be necessary to complete the reaction.

BACTERIAL EFFICIENCY.

As to the efficacy of ozone as a sterilizing agent there is no question, as this has been proven time and again by various investigators. The failure of ozone systems to adequately sterilize certain water supplies has been due not to the failure of ozone as a germicide, but either to the insufficient production of the gas, improper mixture of ozone and water, or insufficient contact.

In the following tables is given the results of tests from the Herring Run plant, showing the exceedingly low concentration of gas necessary for sterilization with sufficient mixture and contact. These results are particularly interesting considering that the supply was not filtered.

TABLE 1.

SHOWING THE EFFECT OF OZONE UPON THE COLOR OF WATER WITH LOW CONCENTRATION OF THE GAS AND UNDER VARYING WEATHER CONDITIONS.

Date.	Color in Parts per Million.		Percentage Removed.	Temperature Air. Deg. Fahr.	Humidity.	Ozone Concentration. Grams of O_3 per Cu. M. of Air.
	Raw Water.	Ozonized Water.				
12/ 3/13	35	15	57.2	48	88	1.69
12/12/13	30	20	33.3	40	58	2.54
4/27/14	28	18	35.7	68	68	0.76
7/27/14	28	20	28.5	80	68	0.90
8/ 5/14	28	20	28.5	80	76	0.84
8/ 7/14	28	20	28.5	78	80	0.63
8/18/14	50	40	20.0	82	80	0.63

Water not filtered before ozonising.

TABLE 2.

SHOWING THE BACTERIAL EFFICIENCY OF OZONE BY PROPER MIXING AND CONTACT AND WITH LOW CONCENTRATIONS.

Date.	Bacteria per C.C.		Percentage Removed.	Temperature Air. Deg. Fahr.	Humidity.	O_3 Concentration.
	Raw Water.	Ozonized Water.				
2/18/14	2.720	25	99.1	30	90	1.05
2/20/14	1 600	16	99.0	24	80	1.77
2/26/14	1 400	8	99.5	34	76	1.26
4/25/14	1 580	56	96.4	54	70	1.27
8/ 3/14	740	16	97.8	78	64	0.58
8/ 5/14	*400	40	90.0	80	76	0.84

Supply unfiltered.

COST OF TREATMENT.

It is rather difficult to give any correct estimate of the cost of treatment in this country, as up until the present time no plant of sufficient capacity has been operated successfully. The cost of sterilization at the Herring Run plant, a ten-million-gallon

* High turbidity in raw water.

unit and in operation five years, cannot be considered as a criterion, as many of the items entering into the operation are development costs and cannot be readily segregated from the whole. Details of operation and construction costs of foreign plants are on file, but these are of little value in determining an estimate of ozone sterilization in this country. An approximate estimate based upon cost of sterilization here will be between $2.50 and $4.00 per million gallons, and considerably less than this if it is not necessary to filter the supply previous to ozonizing. This is based upon a maximum installation cost of $5 000 per million gallons on ten-million-gallon units, or larger installations, which includes roughing filters and refrigeration plant, interest on the investment at 5 to 5½ per cent., depreciation at 5 per cent., current at a maximum of 3 cents per kw., as well as supervision and management.

CONCLUSION.

To recapitulate, ozone treatment for water will be efficient for the following:

Removal of certain organic colors that are present in a water, either in solution or in a colloidal condition.

Elimination, or at least reduction, of odors.

Removal of bacteria without the addition of objectionable chemicals or leaving any detrimental after-effects from the treatment.

It is not the object of this paper to present this method of treatment as a cure-all in the art of water purification, nor, indeed, to lay claim that the system is better under all conditions than the present systems in vogue. It must be granted, however, that there is much that appeals in the method from an esthetic standpoint, and this alone has a value.

There are undoubtedly certain types of water that can be more efficiently and economically treated in this manner than by other systems. I have in mind those classes of waters containing but a slight amount of suspended solids, or suspended matter, in such a state that it can be readily removed by roughing filters operating at high rates; highly colored waters, or well water containing odors or subject to contamination.

It is not surprising that the majority of sanitarians view the value of ozone with considerable skepticism, owing to the failure of the process, either because of high operating costs or inefficient bacteriological results. These conditions have been brought about because of a lack of certain mechanical details in the design and construction of the generators and improper design in the mixing chambers.

From the results of our experimental work we are lead to believe that ozone will be found efficient and economical for water purification, provided that due consideration is given to the adaptability of the method for the particular supply in question, and if the generators and mixing devices are properly designed.

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THE SALEM FIRE.

BY F. A. MC INNES AND CLARENCE GOLDSMITH.

[*Read September 10, 1914.*]

The comparative equanimity with which such a disaster as the recent Salem fire is received by the community in general is little short of marvelous. For a short space of time there is intense interest; the reasons therefor are pointed out; methods of prevention are freely discussed; sympathy is extended in a substantial manner; and yet, the necessary lesson is not learned. What a travesty upon our civilization the story is! The direct fire loss in the United States and Canada in twenty months amounts to a sum of money sufficient to build the Panama Canal: the indirect loss cannot be estimated but is largely in excess of the actual property loss: in addition, enormous sums are spent in maintaining fire departments throughout the country which, owing to conditions obtaining, are powerless to prevent the criminal loss of life and money. With the exception of the present barbaric war in Europe, is there elsewhere throughout the world such an example of preventable waste? It is perfectly obvious to any thinking or unthinking man that the first step to prevent this terrible economic loss is to improve existing conditions; nevertheless, the danger confronting all of our cities and towns is allowed not only to continue but to very greatly increase each succeeding year.

It is the intention of the writers to make an analysis of certain conditions at the Salem fire which have neither been touched on by news items or by reports already published, but which, nevertheless, are of vital importance to those who are devoting their lives to maintaining water supplies adequate for preventing fires from reaching conflagration proportions.

Before the fire was subdued by the flank attack of 27 engine companies, 253 acres were burned over, involving the destruction of over 1 700 buildings at a loss in excess of $14 000 000, all in the short period of thirteen hours. The rapid progress of the fire

can best be shown by the statement that flying embers set fire in South Salem in forty minutes, and by the further fact that the military call was sounded fifty-four minutes from the time the first alarm was given.

The point of origin of the fire, on Boston Street, between Proctor and Pope streets, was immediately adjacent to a 20-in. main of the Salem distribution system where a normal pressure of a little more than 50 lb. obtained. The building in which the fire started, and those surrounding it, were of frame construction and mutually exposed each other, thus enabling the fire to spread with such rapidity that the adjoining buildings were almost immediately involved. Two of these were protected by automatic sprinklers. Before the first hour had lapsed, 10 engines were at work, and a conservative estimate based on a careful study of lengths of hose lines, sizes of nozzles, and water pressures maintained at the engines, shows that at no time during this period was more than 2 500 gal. of water per minute pumped from the distribution system, yet the recording pressure gage maintained by the Salem Water Department on Church Street registered a drop in pressure from its normal of 42 lb. to 20 lb. at the end of the hour.

That these engines with an aggregate rated capacity of 6 750 gal. were delivering this apparently small quantity of water may at first thought seem incredible when the exigency of the occasion is considered, yet a review of actual performances in Boston, where the engines are well maintained and are operated in a skillful manner, where hydrants are closely spaced and much three-inch hose is used, and where the water supply is ample, shows the following quantities delivered at several large fires:

Date.	Location and Alarms.	Capacity of Engine. Gals. per Min.	Maximum Delivery of Engines. Gals. per Min.
7/5/04	B. & M. Grain Elevator, 4 alarms...	12 900	3 500*
7/30/04	B. & A. Grain Elevator, 4 alarms ...	12 000	5 556
11/17/04	Hoosac Docks, 4 alarms.....	12 500	4 653
3/5/10	N. E. Building, 5 alarms.....	16 300	10 400† / 8 330‡
8/9/10	Albany and Dover streets, general alarm	27 700	11 670§ / 15 500‖
6/11/14	Condor and Border streets, 4 alarms.	13 100	6 458

* Hydrants on one side of building only.
† Maximum for ten minutes.
§ For one-half hour.
‡ Average for one hour.
‖ For a few minutes.

In the above figures the amount of water pumped was determined by Venturi meter measurement.

The Marblehead engine arriving at 2.15 P.M. was unable to get water either from the hydrant on Broad Street, between Flint and Jackson streets, or from the hydrant at Broad and Jackson streets, while the Swampscott engine, arriving at 2.10 P.M., and the first Lynn engine, arriving at 2.25 P.M., were seriously handicapped by lack of water.

At the beginning of the fire, the 20 000 000 gal. reservoir was practically full, the two 5 000 000 gal. pumping engines were in operation under a full head of steam, the 30-in. and 20-in. supply mains were in service, and no breaks occurred in the street mains during the progress of the fire.

A test of the carrying capacity of the distribution system was made on August 31, 1914; the method of making this test was as follows:

Four chucks were set on hydrants along Boston and Federal streets, east of Proctor Street. These hydrants were opened, two discharging through three 2½-in. outlets and two through four 2½-in. outlets, and, in addition, a post hydrant in an adjacent alley was discharging through two 2½-in. outlets. The flow from each of the 16 outlets was measured by Pitot tubes and showed a total of 8 585 gal. per minute. The drop in pressure in the 20-in. main at the point where the test was made was observed on the pressure gage attached to a hydrant which was not discharging. This gage showed a pressure of 54 lb. prior to opening the hydrants, and while they were discharging, a pressure of 22 lb., giving a drop of 32 lb. The recording gage on Church Street showed a pressure of 47 lb. before the test, and a pressure of 27 lb. while the hydrants were discharging. The quantity of water obtained shows an abundant supply at this point, an amount in excess of the combined capacity of the engines working at the end of the first hour. A draft from the mains equal to the previously estimated quantity pumped by the engines, namely, 2 500 gal. per minute, would cause a local drop in pressure of less than four pounds. On the date of the fire, the recording gage on Church Street showed 42-lb. pressure when the first alarm was received. In thirty minutes the pressure had dropped to 33 lb., and at the end of the

hour to 20 lb. From this record it is evident that a quantity of water approximately equal to the quantity obtained at the flow test was being withdrawn from the system and the principal object of this investigation is to account for this large rate of flow. One 8-in. and two 6-in. connections supplying the two sprinkler risks already referred to must bear the blame. The 8-in. connection from the 20-in. main was through 25 ft. of pipe to the sprinkler equipment in the Charles H. Keefe plant, and the two 6-in. connections supplying the sprinkler equipment in the Carr Leather Company's plant was fed through 200 ft. of 8-in. main connected to the 20-in. pipe. These buildings ignited immediately, and a large number of sprinkler heads opened in a very short time but were powerless to check the fire, and the collapse of the buildings resulted in the breaking of the sprinkler pipes, allowing the capacity of the three large connections to be wasted from the 20-in. main. To determine the actual effect of these three broken pipes they were opened shortly after the flow test above referred to was made, with the following result:

A gage on a hydrant on the 20-in. main showed a normal pressure of 54 lb., and when the connections were open and flowing, a pressure of 31 lb., which, from the previous flow test, enabled the discharge from these pipes to be accurately determined at 7 200 gal. per minute, a quantity of water in excess of the entire supply required for the fire protection of a city the size of Salem according to the best modern practice: the Church Street gage fell during this test from 46 lb. to 33 lb. The effect of the discharge through these connections is further shown by the recording gage, which continued to drop during the fire as increasing waste was caused by other broken pipes, by increasing demands from the engines, etc.; about 3.00 P.M. it registered 13 lb., about which time a supply at the rate of 8 000 000 gal. per day was delivered from the Peabody system without improving the pressure; at about 5 P.M., the heat had so abated that it was possible to shut the gates during these connections. When this was done the pressure immediately rose to a little over 21 lb. From the previously recited facts it is evident that the broken pipes had so depleted the supply of water that the fire department, of metropolitan size, was seriously crippled within one-half hour, and rendered

almost impotent as the fire progressed. It may be stated that during the progress of the fire, after the pressure was destroyed, two 8-in., eight 6-in., and two 4-in. pipes were discharging into broken inside equipments.

The lesson to be learned from the experience in Salem is that the existence of connections from a distribution system of such size that the quantity of water delivered through them may cripple or destroy the hydrant service is a mistake that surely invites disaster to all water-works systems, and doubly so to those depending upon hydrant hose streams. We recognize the absolute necessity of better building laws, of the general installation of sprinkler equipment, of well-manned and properly equipped fire departments, of uniformity in hydrants and hose threads, of the proper care of explosives and inflammables, of providing for effective direction of the fire fighting forces when the emergency arises, and of an adequate and reliable water supply. But this latter must be safeguarded against such failure as resulted in Salem without detracting from the service which it can safely supply to sprinkler equipments which we believe are invaluable.

The records of fires occurring in sprinkler risks during the past sixteen years show that in 13 691 cases the fire was controlled by the opening of less than 51 sprinkler heads, and in 662 cases only, or 4.6 per cent. of the total, were more sprinklers called upon to open. A 4-in. connection is sufficient to supply 51 sprinkler heads.

All standard sprinkler equipments are fitted with local alarms, and many, through supervisory service, are connected to fire alarm headquarters; in either case the fire department should be promptly notified. In most closely built-up sections, the first piece of apparatus will be on the ground within three minutes, and additional water may be immediately delivered to the sprinklers through outside Siamese connections with which all sprinkler equipments should be provided. The fire department would then have the supply of water under its control, and would be able to deliver it at the seat of the fire rather than use it with little effect as is so often done. Such a method of operation would preclude the possibility of a single large connection menacing the entire community; if any risk is of such special hazard that additional protection is necessary, this should be provided apart

from the public supply either by tanks or other storage. It must be borne in mind that the actual breaking of large connections or of pipes in the equipment connected is not necessary to bring disaster; the opening of too many sprinkler heads may be sufficient to cause serious results, and this might occur in a modern fireproof building which would not collapse and break the equipment or connections.

Three buildings are now standing practically unharmed in the midst of the ruins in Salem, although subject to a fierce trial by fire; they constitute an object lesson in building construction which cannot be forgotten. The three connections discharging at the beginning of the Salem fire should prove an object lesson of equal force.

DISCUSSION.

MR. CLARENCE GOLDSMITH. This question of the size of sprinkler connections appealed to Mr. McInnes and to me, for that is something with which we have both had considerable to do during the last few years. The first attempt with which I am familiar, to get any information together along this line, was made by Mr. Mulholland, of Los Angeles. He believed that there was a possibility of putting in connections so large that there was danger that the water system would be crippled, and, desiring to get all information on the subject which he could, he issued a circular letter to a large number of superintendents throughout the country, got the information together, and tabulated it. I believe that was about ten years ago. He discovered that there were some superintendents and some engineers in charge of works who appreciated the harm that might be done through these connections. Others who had not previously appreciated it, took up the question and considered it more seriously.

The rule in the city of Boston is to limit the size of such connections to 4 in., but more than one connection is allowed if the size of the building warrants. They are generally separated about 50 ft., but are connected with the equipment in the building. This is done with the hope that in case of any rupture in the equipment some of the gates can be closed. But I think that all water-works men appreciate the fact that this is a pretty

slender thread to cling to, for at the time of a fire the superintendent or foreman in charge does not feel that he has the authority to close these connections, and the chief of the fire department is generally very busy attending to other matters, and also he would be rather loath to give the order; and the result is, if the fire is a serious one, that when every one realizes the necessity of closing these connections it is impossible oftentimes to approach the building.

To give an example of the fallacy of the idea of closing the connections, I will cite a fire in the Derby Desk Company at Pittsburg, Pa., where there were two 8-in. connections entering the building. Two emergency crews fully equipped responded from the water department on the first alarm, and within twenty minutes from the time the alarm was received a heavy mass within the burning building fell and broke off both those connections, and it was over an hour before the crew was able to close both the gates. During that time the system was being severely bled, and there would have been a shortage of water except for the very strong distribution system in the city of Pittsburg, which consists of a 36-in. loop with a 12-in. gridiron. Most of our cities could not have stood such a draft.

There are numerous instances where broken connections have seriously handicapped the fire department. The last large fire in Atlanta, Ga., was another example. The fire occurred very near the center of the city, but, owing to the topography of the city, not in the center of the distribution system but on a loop which ran along a street parallel to a railroad yard. A 4-in. standpipe and another large connection failed, and there was considerable difficulty in getting water until the fire had spread to such an extent that it reached back to the larger mains.

The great difficulty at the present time is to get the fire departments educated to use the sprinkler as a part of their equipment. It is only recently that all sprinkler equipments have been required to have an outside Siamese connection for the fire department, and when it appreciates the value of the sprinkler equipment, on account of its ability to deliver water at the seat of the fire, instead of wasting a very large proportion of it, I believe the fire department will use the sprinkler equipment to

its best advantage. If they do so use it they will be able to tell from suitable pressure gages on the line the pressure which is being maintained on the equipment; and if any serious rupture has occurred they will know that it is futile to pump any more water, and they will take their lines off and proceed, as they do in the case of an unsprinklered building, to attack the fire with hose streams.

MR. H. O. LACOUNT. You can overdo a good thing, there is no doubt about that, and you can put in unnecessarily large connections for the sprinkler system as well as for other services. But from the standpoint of our office, backed by a considerable experience with sprinklered risks, we think there is danger in putting in too small connections.

I haven't had an opportunity here to focus my thought particularly on this matter of the size of connections, but one or two things occurred to me while I listened to the latter part of Mr. McInnes's paper and to Mr. Goldsmith's remarks. They both referred to 4-in. connections, of which it would be permissible, according to their idea, to put in several, depending upon the amount of water which is legitimately demanded by the size of the equipment supplied. Now, those various 4-in. connections are connected inside, or brought inside the building into what you may call a header system, and if you wreck your header it looks to me as though you were going to waste as much water through several 4-in. connections as you would through one large connection passing the same point where the header system is located. Then, furthermore, an objection to small connections in multiple is that you complicate your system. You have a number of additional valves, which it is a care to maintain, and one thing which I think the sprinklered risk jurisdiction fears as much as anything is a closed valve. A closed valve on the sprinkler system is as disastrous as no connection at all, until it is opened; and, therefore, the more valves you put in, necessitated by an additional number of the smaller connections, the more you increase the chances that the valves will not be open when the emergency comes. Therefore it seems to me that a reasonably good-sized connection, — not too large, but certainly in many cases as large as 6 in., and under some conditions even larger, —

is as safe as the other and in some ways much preferable, and, therefore, I certainly would advocate in certain places connections larger than a 4-in. I think a 6-in. connection is entirely reasonable under proper conditions, and, for purposes of control, which would be desirable, I believe it is generally possible to so locate the controlling valve that, barring a conflagration when everything is driven off the street, you would be able to get at the valve in case of really serious trouble with the building. Block control by valves located at street intersections would still be available for preventing waste when local control valves could not be reached.

MR. GOLDSMITH. It was not my intention to convey the idea that either I or Mr. McInnes believe in these multiple connections. I merely suggested that as the ordinary method of handling the situation in the city of Boston at the present time. I think our paper brings out the fact that we believe in having but one connection, because that will handle 95.4 per cent. of the fires, and in the cases of those that cannot be handled that way the supply can be augmented by connections by the fire department.

In dealing with this subject we have been considering only built-up areas with risks which expose other buildings, and, as I believe Mr. Lacount represents a company which to a greater or less extent is dealing with risks which are more or less isolated, many of which are of especially high hazard and require large connections, I believe in such cases it is highly desirable and permissible to give a connection that will be ample for the number of sprinklers which a fire will open. The problem is somewhat different, however, when you come to closely built-up down-town sections.

MR. MCINNES. I wish simply to supplement what Mr. Goldsmith has said, for it is evident that Mr. Lacount has misunderstood, to some extent, our position. We have given no hint in our paper that we believe in a number of 4-in. connections, and Mr. Goldsmith in stating the Boston practice does not endorse it. This practice is based on the idea that the separation of the pipes lessens the danger of complete failure from falling walls cornices, etc., and, further, that it might be possible to shut one

pipe off when another could not be reached: the principle is carried still further by taking the pipes from different sides of a building when possible.

I, personally, think our policy is a mistaken one; in closely built-up sections the rule of one pipe only, not exceeding 4 in., with outside connections to sprinkler equipment to be used by first engine responding if the fire is an inside one, is the greatest safeguard against disastrous fires.

Mr. Gorham Dana. I represent the Underwriters' Bureau of New England, and we have a great many risks in congested districts as well as in isolated districts. We believe, with Mr. Lacount, that a limit of four inches for the size of connections would be unfortunate. There are a great many large buildings in the cities where the sprinkler system cannot be properly supplied by a 4-in. pipe.

It has been mentioned that a large proportion of fires do not open more sprinklers than will be supplied by a 4-in. pipe. That is very true, but we want to take care of the remainder if we safely can. I think different cases have got to be treated more or less on their merits. In some cases it might be undesirable to put in larger than a 4-in. connection, while in other places, where the valve can be located at some distance from the building, it may be perfectly safe to put in a larger one.

It seems to me that this Salem fire presents another phase which might be considered, and that is the necessity of preventing the start of a conflagration by putting sprinklers in all buildings which are liable to cause conflagrations. This particular fire started in a very large frame building used for very hazardous processes, including celluloid working; and there is absolutely no question in my mind, nor in the minds of many others, that had that building been equipped with sprinklers there would have been no conflagration. Now, isn't that the best end to work on, — that is, to prevent the start of fires? I do not believe that any rules which anybody can make will properly take care of a conflagration. A conflagration is one of those things which, when it gets going, is beyond human ingenuity to cope with. I don't believe that additional water pressure in Salem would have helped materially, because they did not have the force to handle it. You

cannot do anything against a conflagration except by attacking the edges of the fire. One trouble in Salem was the fact that the fire department was undermanned when the fire began. They had a force, as I recall it, of about 23 men. Five of those men, I think, — I am not exactly sure of the figures, — were off duty, it was their "day off," and I think nine were at lunch, so it left less than half the normal force. That was one of the troubles. The next trouble was that when they started to fight that fire one of the chuck hydrants broke, — I think the second one they tried to use went out of commission, — and that delayed them at a very important point. If they had been properly manned and had got to the fire quick enough, they probably would never have had these broken sprinkler connections.

Another feature is the chuck hydrant. That is probably not being installed much to-day; it is rather an out-of-date device, perhaps. But still this fire brought out its undesirability very strongly, because the out-of-town departments were absolutely useless unless they could get one of those chucks, and there were not very many extra ones to be had, so that many of the out-of-town departments had to stand by and do practically nothing, because they couldn't connect with the water pipes. It seems to me that some discussion along those lines might possibly be of profit.

Mr. Dexter Brackett. The last speaker referred to the Lowry hydrant, or the hydrant used with a chuck, as being out of date or antiquated, but I well remember the first use of that pattern of hydrant in Boston, in 1869 or 1870, and at that time it was certainly a great advance over the patterns of hydrants then in use. As this pattern of hydrant is placed directly over the pipe from which it is supplied, and in many cases at the junction of two pipes, and the hydrant itself is generally 9 in. in diameter, it has a large capacity, and being located in the center of the roadway is conveniently accessible to several engines. It has the disadvantage of being hidden by snow and ice in the winter, and of requiring time for making connections between the engines and hydrant by the use of a chuck which may not be carried by engines from neighboring towns.

It occurred to me as Mr. Dana was speaking that the solution

MIDDLETON
LYNNFIELD
PEABODY
DANVERS
SALEM
BEVERLY
SALEM HARBOR
MARBLEHEAD
SKETCH SHOWING WATER SUPPLIES
& ASSISTANCE RECEIVED DURING FIRE
SALEM

PLATE I.
N. E. W. W. ASSOCIATION.
VOL. XXIX.
MC INNES AND GOLDSMITH.
THE SALEM FIRE.

of this bugaboo of bad risks is largely in the hands of the insurance men. If they would simply refuse to insure such risks I think they could force the owners to take the proper precautions and install sprinkler systems. I have found within the last few years an amazing ignorance among owners of property as to even the existence of such a thing as a sprinkler system, and I find that when I take the matter up with them and explain it, it often results in the installation of a sprinkler system, and that they are able to save the cost of its installation in the saving in insurance within a few years. I think if that was put up to the men who own such risks, with a refusal to insure under existing conditions, it would make the introduction of the sprinkler system more general.

Mr. Dana. In reply to the last speaker, I will say that I think the insurance companies do encourage the installation of automatic sprinklers, but there is a good deal of competition in the business, and there are always companies ready to insure what other companies will not. There are a great many foreign companies doing business in this country which are anxious to get business on almost any terms, and it is pretty difficult to say that no company will insure a plant which is not in good condition.

One feature in regard to the Salem fire which occurred to me was that, so far as I know, none of the steamers lacked water; that is, there was enough water in the pipes at all times to supply the steamers. Under the conditions it seemed to me that the system held up remarkably well, — I think fully as well as would occur in the water works in most towns of the size.

Mr. R. C. P. Coggeshall. I would like to ask Mr. McInnes at what stage of the fire the cement-lined mains ruptured.

Mr. McInnes. That occurred after the fire had been subdued, and the pressure had risen to practically its normal. It was high pressure which caused the break in the main, not the low pressure.

Mr. T. H. McKenzie. As I gathered from Mr. McInnes, the large trouble in Salem was the reduction of pressure and the loss of water due to the breakage of some of the large connections with the sprinkler system in some of the large factories. The gates in pipes leading to the burnt factories not having been closed, a large amount of water ran to waste and reduced the pressure. I think he should have followed that up with some

recommendations as to the method of controlling or operating the gates which control the supply into sprinkler systems, after they cease to be of service. If there were a number of 6- or 8-in. pipes broken, it isn't strange that there was no water pressure.

MR. MCINNES. I might say that the history of this fire answers that question. The sprinklers must have been fully going within a half hour or less from the time the fire started, and the connections must have broken within, certainly, three-quarters of an hour; but it was two and a half hours later before it was possible for any human being to get to the gates and close them, on account of the heat.

MR. WALTER O. TEAGUE. On the afternoon of the Salem conflagration, Mr. E. V. French, of the Arkwright Mutual Fire Insurance Company, and I went to the Naumkeag Steam Cotton Company mills and saw that they were prepared to make a fight if the fire came near them.

There was practically no city water pressure, but the mill firemen had the two 1 000 gal. fire pumps going taking suction from the harbor and throwing a good stream on the fire traps nearby, to wet them down.

The fire spread through the thickly built-up section to the southwest, on the windward side of the plant, and before we realized it it was down on the mill. We attempted to make a stand to resist the advance of the fire from the windward side. I would know better the next time than to do that, but it was quite the natural thing to do. But you have got to fight these conflagrations on the windward edges and not on the leeward side, because it is impossible, of course, to withstand the heat there long enough to apply the water. We found that out very quickly and in fifteen minutes we were driven back gradually and had to abandon the hose. Fortunately we were able to shut off the streams at the hydrants which were in use, as we went backwards towards the mill.

We fought there for two solid hours, and the men were practically all in and were physically unable to do much more. It developed that that didn't really count after all, for the only hope of saving the plant was the automatic sprinklers. As we gradually shut down the streams the sprinklers came into play, and as they

opened they drew down the pressure somewhat, until finally, at the height of the fire, one of the pumps failed us, the pin on the sleeve of the piston rod working loose, and the pressure dropped to 10 lb. It was put back into commission in twenty minutes, but twenty minutes at that time seemed like several hours. When we got the pump finally going again we got the pressure up to about 20 lb., and that is about as high as we could get it. It was evident that so many sprinklers had opened while the pressure was down, with only one pump running, that we could not get it back again. We then decided to close some of the gates in the yard mains to sprinkler systems in the buildings at the south end of the yard, but the fire had got into a four-story wooden mill building which was completely sprinklered, but with the low pressure the sprinklers were not effective, and in the few minutes while the pump was shut down the building burst into flame. The tremendous heat and fire from that building swept down on to the indicator posts which were some fifty feet from the building, and prevented us from getting at the valves so as to shut off these southern buildings.

In the hope of saving as much of the plant as we could, we shut the division gates, where we could get at them by shielding the man at the valve by our coats. That raised the pressure up to 120 lb., and it held there for half an hour or so and then gradually it began to go down, until we had to leave the plant at a little after ten o'clock, because the fire came into the boiler house and drove the firemen out. In half an hour the pressure had dropped to about 80 lb. That showed that even in those buildings which were quite remote from the burning district a great number of sprinklers were opening. Nevertheless, the sprinklers held the main building, which is on the bank of the river, until one o'clock in the morning, and we thought for a time that it would pull through. But finally the fire got into that, and in fifteen minutes the walls of the building began to fall.

The speed of the fire through those buildings was astonishing. They were of plank and timber construction, with brick walls and cast-iron columns, but in fifteen or twenty minutes from the start of the fire in those buildings the walls began to fall, and of course later developed into a total loss. I don't know, of course, how

long the pumps ran, but it seems as though they must have run pretty well on towards half past eleven or twelve o'clock to hold the fire back as well as they did.

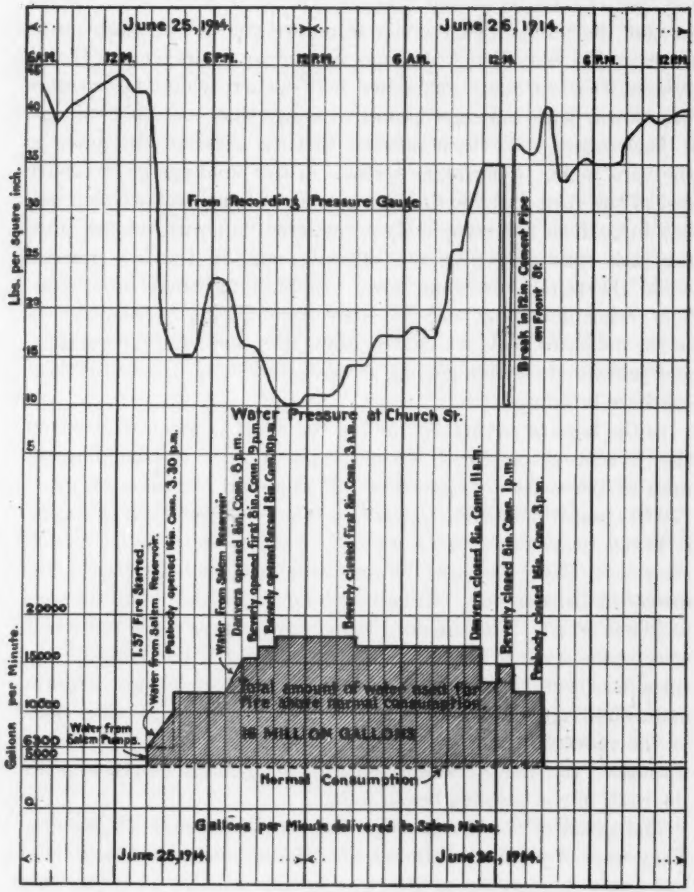

June 25, 1914.
June 26, 1914.
6 P.M.
12 M.
6 P.M.
12 P.M.
6 A.M.
12 M.
6 P.M.
12 P.M.
Lbs. per square inch.
From Recording Pressure Gauge
Water Pressure at Church St.
Break in 8 in. Cement Pipe on Front St.
1.37 Fire Started.
Water from Salem Reservoir.
Peabody opened 16 in. Conn. 3.30 p.m.
Water from Salem Reservoir
Danvers opened 8 in. Conn. 6 p.m.
Beverly opened first 8 in. Conn. 9 p.m.
Beverly opened second 8 in. Conn. 10 p.m.
Beverly closed first 8 in. Conn. 3 a.m.
Danvers closed 8 in. Conn. 11 a.m.
Beverly closed 8 in. Conn. 1 p.m.
Peabody closed 16 in. Conn. 3 p.m.
Gallons per Minute.
Water from Salem Pumps.
Total amount of water used for Fire above normal consumption.
18 MILLION GALLONS
Normal Consumption
Gallons per Minute delivered to Salem Mains.
June 25, 1914.
June 26, 1914.

FIG. 1.

CHARLES H. SMITH. Being of the insurance fraternity I have had opportunity to study the Salem fire and the lessons to be drawn from it. To my mind the two main features are the very poor construction of that part of Salem, especially where the fire started, and the fact that the large factory in which it started lacked automatic sprinklers. I think that if it had had them and a supply pipe of liberal size, Salem undoubtedly would be to-day where she was before the fire. There is no question but that at the start of the fire there was a 20-in. pipe in front of that building, with about 50 lb. pressure on it, and that the firemen with that water supply were unable to stop the fire when it started.

Another interesting thing to me is the fact that the speaker has recommended steamer connections to all sprinkler systems. That is something that the insurance people as a rule have tried to get for a great many years. We are meeting with some success, and in a number of the largest cities it is now the rule that the steamer connections shall be provided when sprinkler systems are installed. But it is still more or less difficult to educate the fire department up to connecting to those steamer connections, even when they exist. We will all welcome the day when the fire departments are instructed to connect the first line of hose of the first steamer to those sprinkler connections.

Another point is that I think the presence of cement-lined pipe in the Salem streets was somewhat of a deterrent to the outlying towns which had connections with the Salem service from turning their water into the Salem pipes, until they were sure that there was sufficient draft so that their higher pressure would not rupture the Salem pipe.

We made a plot of the total amount of water used during the Salem conflagration and figured that it was about 16 000 000 gal. above the normal use, from the start of the fire up to two o'clock on June 26, the next day.

MR. MCINNES. One thing that struck me very strongly during the fire, and later when looking over the ruins, was what the firemen were able to do under exceedingly adverse conditions. Before leaving one point of the fire Mr. Goldsmith and I spoke of a church and several other buildings, agreeing that they were

doomed; yet, to our surprise, we found them safe and sound the next day. The "stop" seemed a remarkable one, for we knew from our own observations that the supply of water at that point was very poor indeed. A walk along the outskirts of the fire, the following day, gave the same impression; there were many cases where it seemed marvelous that the firemen were able to make a successful stand under the conditions.

The query naturally arises, What would have been the result in Salem if the water supply had been even reasonably sufficient?

MR. J. M. DIVEN. The Salem fire has certainly taught us the necessity of exercising more care in the installation of fire and other large services. It would seem as if the lesson must have been impressed upon the insurance people, so that they would realize the justness of our claims for safeguards on such services.

It is possible to locate all such services so that they can be controlled and shut off in case of necessity, that is, when it is found that they are crippling the water service. The owners of buildings naturally want the services put in in the shortest and cheapest way, and possibly the insurance interests agree with them in this, as cheap installations encourage their adoption; but the water-works people should insist on proper location of such services, and of all possible safeguards. It is always possible to so locate such services that the indicator post valve, and one should always be insisted upon, will be accessible, no matter how bad the fire is in the building supplied. For buildings located near the street line, the fire services can be run across the street with an indicator post valve at the curb line opposite the building, and a return pipe to the building. If this longer service, with its bends, is objectionable on account of friction, a larger pipe can be used. Or the tap can be made a hundred or even a thousand feet from the building, an indicator post put at the curb line opposite the tap, and the service run to the building. Such installations would be high in first cost but cheap if they saved the city from a conflagration.

Two four-inch services instead of one six-inch are all right if they are taken from different streets, or from points in a water main separated by a gate valve; otherwise they are about as great a menace as the one large service.

MR. JOHN C. WHITNEY. I would like to ask Mr. Diven if he has found it feasible to put into practice in his system what he professes.

MR. J. M. DIVEN. No, sir; Troy is as lacking in regulations of this kind as it is possible for a city to be, and an attempt to pass an ordinance for the control of fire services was defeated. However, there is one proper installation, made so voluntarily by the mill owners. It has two services, separated by a valve in the main, and both provided with indicator post valves at curb opposite the building, with return pipes. Even should the walls of this building fall out, the indicator post valves could be reached, as the street is much wider than the height of the building.

MR. GOLDSMITH. I would like to employ a little simile in a parallel case to delivering a large quantity of water for fire purposes.

There are a number of high buildings in most of our cities which it is impossible to serve under existing conditions on account of lack of pressure. We have several here in Boston which have to pump their water to the higher stories. I am pretty sure at the new Custom House they will have to pump water to the upper stories, and they certainly have to in most of the buildings in lower New York, and in Buffalo almost every building in the down-town section has to pump its water. If 75 lb. is to be maintained in the business district it will be necessary for a number of the buildings to pump the water. Now, take the case of the Woolworth Building, for instance; we wouldn't think for a minute of maintaining pressure enough on the city mains to supply it, and why should we endeavor to furnish water in large quantities in order to take care of these special risks, when these buildings do their own pumping and don't for an instant expect the city to deliver the water in their upper stories?

Both Mr. McInnes and I will admit that a sprinkler equipment in the building where the Salem fire originated would probably have stopped the fire at that point. But we also believe that if the system had been supplied with a 4-in. connection the same result would have been obtained; and from what we were able to see of the fire it seemed to us that if the supply had been

available in certain portions of the city where there was no supply when we went through those streets the fire could have been considerably narrowed up, although, of course, it would have covered a large area any way.

The water-works men and the men who represent the insurance companies are all working to the same end. There seem to be some few points on which we cannot agree, and one is the closing of the connections. Mr. Teague cites the case of the cloth mill, when both he and Mr. French were present, and he says it got so hot that they couldn't close the gate, — I presume it was an indicator post, because it is the custom of the Factory Mutual Companies to set indicator posts. Now, if Mr. Teague and Mr. French were not able to determine the time to shut it, how can we expect an emergency crew with a foreman to be able to determine the time to shut off a connection? I believe, from my point of view, that such arrangements must be made that we shall not have to depend upon any human effort to control the supply.

The idea of putting in long connections would apply in some cases, but in many of our large cities it would be absolutely impossible to lay the connection for any distance, and in most cases it is very difficult to get the connection indirectly from the main.

Mr. Lacount. Mr. Goldsmith suggests that a 4-in. connection would have probably been large enough for the factory where this fire started. I agree with him, provided a 4-in. connection was big enough to supply all the sprinklers on the floor where the fire started, because in this case, with the explosion of this very combustible material, no doubt the fire went through that whole story before the first sprinkler which opened could really get into operation and, therefore, this is a case where all the sprinklers for which any service connection would be laid out to-day would probably open very soon, and it is an example of where a full-sized connection would be necessary for good protection.

But it seems to me that the lesson of the Salem fire is not really one of large or small connections or of one or more small connections or of the location of gates. It seems to me the lesson

is that when you have got a conflagration on your hands you cannot stop it. The best solution of the problem is to not have a conflagration, and one of the best ways to avoid it is to build better and to guard what you build with automatic sprinklers and the ordinary means for fire protection.

It seems to me that above all these other considerations this Salem conflagration calls our attention very strongly to the necessity of better building construction. We want the protection that the sprinklers give us, we want good sized connections, we want a good water supply, but Salem needed better construction, and if it had had that, the fire would not have gone to the mills and the mills would not have been destroyed.

There is only one thing I know of, backed by some experience, that will stop a conflagration, and that is something of the nature of the Atlantic Ocean. That was sufficient for the job at Salem. I have heard the question asked, Where does a fire go to when it goes out? I will tell you where this one went; it went out to sea. I was down there and saw it go. There was fuel enough in Salem to have furnished energy sufficient to keep it moving yet. There was a lot of combustible material in Salem, and when it got under way there was nothing that could stop it, whether there was a 4-in. or an 8-in. connection and whether these were intact or broken off. They did stop it at the outskirts, but the conflagration itself burned to the sea.

Mr. Frederic P. Stearns. Mr. Chairman, nobody has had the temerity to suggest that it might be possible to use a pipe large enough to furnish all the water that the sprinklers could take, and have placed on it some automatic arrangement by which the water would be shut off when the velocity became too great. I don't think it practicable to do this, and yet I don't like to say that anything is impossible. Some of the inventors should try to do it. The subject has been brought up in the city of New York, and I think Mr. Flinn can tell us how they propose, in the case of the break of a 48-in. pipe under about 300 ft. head, to prevent the flooding or submerging of portions of Manhattan by the supply that can come through a 14-ft. tunnel.

Mr. Alfred D. Flinn. The type of valve to which Mr. Stearns refers is quite unusual. Catskill Mountain water will

be delivered into the mains under the streets of New York City through a pressure tunnel, deep in the rock, eighteen miles long. This tunnel extends from the Hill View reservoir at the northerly boundary of the city to the heart of Brooklyn. In constructing it, twenty-four shafts have been used, and of these, twenty-two will serve as connections from the tunnel to the street mains. Into these shafts one, or in some cases two, riser pipes of steel plates will be built, embedded in the concrete filling of the shaft and lined with concrete. Most of these risers are 48 in. in diameter, but a number are 72 in. At the top of each riser is a bronze "T," called a shaft cap. To each outlet flange of each shaft cap will be bolted an all-bronze gate valve, and beyond these bronze valves there will be the necessary cast-iron pipe specials, iron controlling valves, and pressure regulators. The special valve to which Mr. Stearns refers is known as a riser valve and will be placed in the riser about 100 ft. below the top of sound rock. The usual arrangement of a shaft with its riser valve, shaft cap, and chamber is shown by an accompanying illustration (Fig. 2), which also shows in some detail the design of the riser valve and shaft cap.

The riser valve, which is of the needle type, consists essentially of a bulbous enlargement of the vertical riser, a long spindle-shaped, or top-shaped, plug having vertical motion in the enlargement, and a removable seat ring at the top of the enlargement, forming a contracted throat smaller than the plug and upon which the plug, rising with the current, closes. A hydraulic cylinder within the plug and a fixed piston supported from the seat ring, together with devices for regulating discharge from the cylinder, control the closing of the valve. In the drawing, which shows a 48-in. riser valve, the plug or moving part, where in section, is rendered in solid black to differentiate it from the stationary parts which are hatched, although the material, manganese bronze, is the same in both.

The upper part of the plug encloses and is guided by a 7-in. vertical cylindrical stem or piston rod, which is cast integrally with a three-armed spider and the seat ring. The lower end of the stem carries the piston. The plug is further guided with respect to the piston by a $4\frac{1}{2}$-in. tail rod projecting from the piston

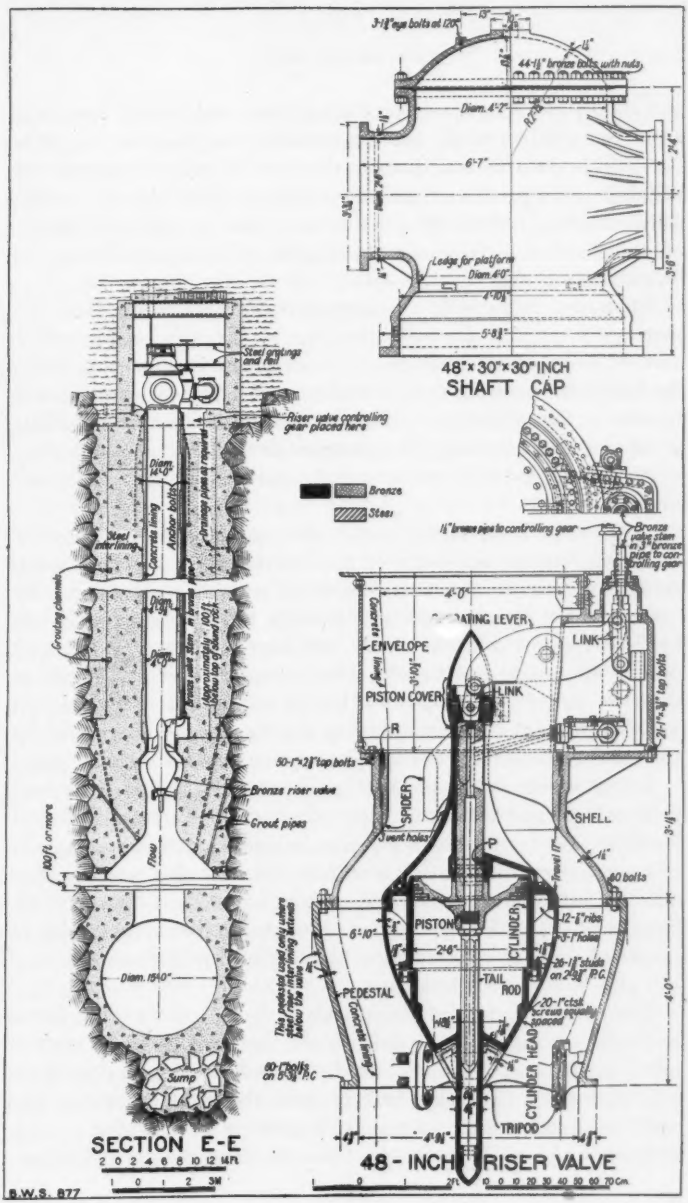

48"×30"×30" INCH
SHAFT CAP
SECTION E-E
48 - INCH RISER VALVE
Bronze
Steel
ENVELOPE
PISTON COVER
PISTON
CYLINDER
SPIDER
SHELL
TAIL ROD
PEDESTAL
CYLINDER HEAD
TRIPOD
LINK
Bronze riser valve
Grout pipes
Steel gratings and rail
Riser valve controlling gear placed here
Concrete lining
Steel shell
Anchor bolts
Grouting channels
Sump
Diam. 15'0"
B.W.S. 877

FIG. 2.

and sliding in a long sleeve projecting from, and formed integrally with, the cylinder head, and constituting the point of the plug. Grooves in the tail rod permit the flow of water between the cylinder and sleeve as the valve moves. The sleeve in turn slides in the hub of a fixed three-armed spider, marked " Tripod " on the drawing, forming an outside guide at the extreme lower end of the moving plug.

When the valve is in its normal or wide-open position, the plug rests on conical steady bearings at the hubs of the spider and of the tripod. These conical bearings are designed to prevent oscillation of the plug due to eddies in the flowing water and so to relieve the cylindrical guide surfaces from wear. The tripod is capable of supporting the whole weight of the removable parts of the valve above it, including the piston and spider, as well as the plug.

Ports through the piston, piston rod, and one arm of the spider establish a connection between the cylinder and a 1½-in. bronze pipe extending to the valve chamber at the shaft head. By forcing water into the cylinder through this pipe, the plug can be forced down and the valve opened; conversely, when this pipe is opened to the air the excess pressure which will exist in the riser outside the plug over that in the cylinder will force the valve to its seat. The rapidity of closing will be determined by the rate at which water is allowed to escape through the 1½-in. pipe.

An operating rod connected to the plug through a lever and links will extend from the riser valve to the valve chamber at the shaft head, affording a position indicator, an auxiliary means of operation and a partial counterbalance for the moving plug. The rod works in a bronze pipe slightly larger than the rod couplings, this pipe, like the 1½-in. pressure pipe, being embedded in the shaft concrete. A stuffing box at the top of the operating-rod pipe will prevent leakage.

The piston cover has three functions, — to connect the cylinder to the operating lever, to smooth the waterway, and to exclude grit which might otherwise reach the piston rings and cylinder and score them and cause leakage from the cylinder, and so permit too rapid closing. Since deep pockets in the piston cover are necessary under the spider arms to allow the valve to close,

and since grit might enter between piston cover and piston rod through these pockets, a packing ring, *P*, is provided between piston rod and piston cover below the bottom of the pockets.

Three tapped vent-holes are provided in the piston cover to permit free flow of water to or from the space between piston and piston cover as the valve moves.

The piston rings are similar in shape and action to the familiar cup-leather packings, but are made of manganese bronze about $\frac{3}{32}$ in. thick, beaten to shape, annealed dead soft, and ground on their outer circumference to a diameter slightly greater than that of the cylinder. The cylinder is carefully ground to exact and uniform diameter.

The lower three piston rings are to prevent escape of water from the cylinder when the pressure in the cylinder is being maintained to prevent too rapid closing of the valve. The upper, reversed ring is to prevent leakage into the cylinder when the pressure in the cylinder is reduced to force the closing of the valve. This reversed ring also is to act as a guard and scraper to protect the rings below. This construction has resulted in an extraordinarily small leakage past the piston, the valves when tested leaking in no case more than one gallon per hour at 600 lb. per sq. in. In each case the piston was stationary during the test. Prior tests on a 12-in. model with ground steel cylinder and one brass ring of the same construction showed substantially the same leakage whether the piston was stationary or moving.

In order that the riser might be used as a hoisting shaft, should repairs in the tunnel become necessary, it was required that all parts of the valve within the waterway should be removable. To this end the spider locks into the throat of the shell somewhat as the breechblock of a cannon locks into the breech; the detail, however, is simpler, there being only a single ring of matching lugs on the spider ring and on the shell.

Mr. Dana (*by letter*). — An inspector of the Underwriters' Bureau of New England was in Salem when the conflagration broke out, and reached the Helburn Leather Company on Goodhue Street, about 600 ft. from the fire, fifteen minutes after the alarm came in. He noted that the water pressure on their gage was 20 lb., the normal pressure being 40 to 48 lb. At that time

none of the sprinkler pipes had broken, but a few sprinklers in the Chas. F. Keefe risk had undoubtedly opened, because the water flow alarm from their system was received by the American District Telegraph Company at Peabody at 1.49, or ten minutes after the public alarm was sounded. No other buildings equipped with sprinklers had taken fire at this time. There was a 2-in. domestic-service pipe running into the Creedon Building, where the fire started, and this was probably broken early in the fire.

In this connection it is interesting to note that last winter, during a cold snap, the water pressure at City Hall dropped to 25 lb. from a normal pressure of 40 lb. on account of consumers opening their faucets enough to prevent freezing during the night. The National Board of Fire Underwriters' tests in September, 1914, with two 6-in. and one 4-in. sprinkler connections at the Keefe and Carr Leather Company's plants open, showed a drop in pressure of 23 lb., which is about the same as that caused by the opening of faucets to prevent freezing.

All this would seem to show that the loss through broken domestic-service pipes was as much if not more than that from broken sprinkler connections, and that, therefore, the breaking of sprinkler connections was not the principal cause of the drop in pressure during the conflagration.

Mr. McInnes and Mr. Goldsmith (*replying to Mr. Dana's discussion by letter*). — The authors are confident that the gage readings at the Helburn Leather Company are misleading and erroneous as indicating conditions existing on the distribution system. Our reason for this statement is the conclusive fact that the actual drop in pressure on the system at the end of the first fifteen minutes was 4 lb. as recorded on the gage of the Salem Water Department at Church Street; this drop means a draft of not more than 2 500 gal. per minute. It is evident that the gage readings given by Mr. Dana cannot represent the actual pressure on the distribution system but must be otherwise explained; for example, by incorrect gage, by local draft, etc. We agree the loss through broken service pipes to have been very serious as the fire progressed, but we positively know the loss from this cause was negligible through the first hour of the fire, the period covered by our paper and on which our argument is based.

MR. W. S. JOHNSON * (*by letter*). In a discussion of the lessons to be learned from the Salem fire, it may be of interest to know some of the things which the city itself has learned. In the first place, it has learned the value of good neighbors. Water was used during the fire at a rate of 17 000 gal. per minute, and of this the city could furnish only 7 000 gal. per minute. The remainder was supplied by the neighboring cities and towns through connections which had been provided for such a contingency. Had these connections not been available, parts of the city would have been absolutely without water.

The town of Marblehead, one of the neighbors, was unable to give assistance, as the principal part of the supply for this town is pumped by electricity furnished from the power station in Salem, which was put out of commission by the fire. While Marblehead might get a partial supply from the neighboring town of Swampscott, it is certain that it would have been difficult to fight even a small fire in that town had one occurred during the Salem conflagration. The lesson as to the unreliability of electrically operated pumps is obvious.

The most important lesson which Salem has learned is the necessity of being able to deliver an ample supply of water under a proper pressure with which to fight fires. This was thoroughly realized by the officials in charge of the water department, and the city engineer had already made plans for such a supply. The water department was making a net profit of from $60 000 to $70 000 per year, but there were so many other uses for the money that the construction of the high-pressure system was postponed. The introduction of a higher pressure involved the relaying of about twenty miles of cement mains which were not capable of standing the increased pressure, as well as the construction of a new reservoir, pipe line, and pumping machinery. As a result of the fire, work on this new system is already under way, and when completed the city will itself be able to furnish as much water as was used during the fire with a sufficient pressure for hydrant streams.

While the quantity of water available was apparently sufficient to supply steamers at all times, with possibly one exception,

* Sanitary and Hydraulic Engineer, Boston, Mass.

there was not enough pressure to enable the householders to protect their roofs from sparks. With sufficient pressure the householders could have done much to prevent the spread of the fire by protecting their own roofs.

As to the sprinkler connections referred to by the authors, it is certain that the bleeding of the system through these connections and through the great number of house connections was very great, and it was impossible to get at gates to shut them off. It is doubtful, however, if smaller connections would have had any effect in preventing the spread of the conflagration, but it seems reasonably certain that more sprinkler connections would have checked it. If the factory in which the fire originated had been provided with sprinklers, it would probably have been possible to have confined the fire to that immediate vicinity.

Messrs. F. A. McInnes and Clarence Goldsmith. The authors must take exception to Mr. Johnson's statement that "the quantity of water available was apparently sufficient to supply steamers at all times with possibly one exception." Our exception is based both on personal observations during the fire and upon the testimony of many responsible firemen. The evidence is conclusive that the steamers could not obtain a sufficient supply of water during the first hour; this handicap increased as the fire progressed, and further waste was caused by breaking of other large connections and of service pipes.

PROCEEDINGS.

Annual Meeting.

Hotel Brunswick,
Boston, Mass., January 13, 1915.

The President, Frank A. McInnes, in the chair.

The following members and guests, among whom were a large number of ladies, the day being known as "Ladies' Day," were present:

Honorary Members

Desmond FitzGerald and F. P. Stearns. — 2.

Members.

R. C. Allen, S. A. Agnew, L. M. Bancroft, Dexter Brackett, E. C. Brooks, James Burnie, J. C. Chase, R. D. Chase, G. W. Cutting, Jr., J. M. Diven, John Doyle, E. D. Eldredge, G. H. Finneran, F. F. Forbes, A. S. Glover, J. M. Goodell, R. K. Hale, F. E. Hall, L. M. Hastings, A. R. Hathaway, D. A. Heffernan, D. J. Higgins, A. C. Howes, W. S. Johnson, Willard Kent, S. E. Killam, Morris Knowles, C. F. Knowlton, T. E. Lally, F. A. McInnes, Hugh McLean, J. A. McMurry, H. B. Machen, H. V. Macksey, A. E. Martin, John Mayo, F. E. Merrill, G. F. Merrill, H. A. Miller, F. L. Northrop, T. A. Peirce, J. Harold Remick, L. C. Robinson, A. T. Safford, G. A. Sampson, P. R. Sanders, Carleton Scott, C. W. Sherman, E. C. Sherman, J. Waldo Smith, G. A. Stacy, R. H. Stearns, W. F. Sullivan, C. N. Taylor, D. N. Tower, J. H. Walsh, R. S. Weston, G. C. Whipple, J. C. Whitley, F. I. Winslow. — 60.

Associates.

Builders Iron Foundry, by A. B. Coulters; Chapman Valve Mfg. Co., by J. F. Mulgrew; Darling Pump and Mfg. Co. (Ltd.), by H. A. Snyder; *Engineering Record*, by I. S. Holbrook and Burdette Phillips; Gamon Meter Co., by J. S. Eggert; Hersey Mfg. Co., by A. S. Glover and S. B. Greene; Lead Lined Iron Pipe Co., by T. E. Dwyer; Mueller Mfg. Co., by G. A. Caldwell; National Meter Co., by J. G. Lufkin and H. L. Weston; National Water Main Cleaning Co., by B. B. Hodgman; Neptune Meter Co., by H. H. Kinsey; Norwood Engineering Co., by H. N. Hosford; Pitometer Co., by E. D. Case; Pittsburgh Meter Co., by J. W. Turner; F. H. Hayes Machinery Co., by F. H. Hayes; Rensselaer Valve Co., by C. L. Brown; A. P. Smith

Mfg. Co., by D. F. O'Brien and F. L. Northrop; Standard Cast Iron Pipe and Foundry Co., by W. F. Woodburn; Thomson Meter Co., by E. M. Shedd; Union Water Meter Co., by F. E. Hall; Water Works Equipment Co., by W. H. Van Winkle, Jr.; R. D. Wood & Co., by C. R. Wood and N. M. Simmons; Henry R. Worthington, by Samuel Harrison and W. F. Bird. — 30.

GUESTS.

Mrs. S. C. Prescott, Mr. and Mrs. W. B. Webber, Mrs. F. F. Forbes, Brookline, Mass.; E. A. Pike, water commissioner, Groveland, Mass.; Mr. G. A. Stowers, Billerica, Mass.; Mrs. Samuel Harrison, Mrs. D. L. Dow, C. R. Hildred, Somerville, Mass.; Mrs. E. E. Martin, Mrs. C. F. Knowlton, Mrs. E. C. Brooks, Melrose, Mass.; Mrs. John Mayo, Bridgewater, Mass.; Mrs. Albert S. Glover, Mrs. Dexter Brackett, Mrs. F. I. Winslow, Mrs. F. A. McInnes, Mrs. G. A. Caldwell, Dr. and Mrs. Allan McLaughlin, H. F. Fiske, J. A. Tomasello, Boston, Mass.; Mrs. C. W. Sherman, Belmont, Mass.; Miss E. Mellen, Mrs. D. J. Higgins, Waltham, Mass.; Mrs. E. B. Hamlin, Providence, R. I.; E. P. Lane, Manchester, Mass.; Dwight L. Agnew, Scituate, Mass.; H. A. Bancroft, Reading, Mass.; J. E. Shredo, Holyoke, Mass.; Mrs. G. C. Whipple, Cambridge, Mass., and George W. Taylor, New York, N. Y. — 32.

After dinner, during the serving of which there was vocal and instrumental music, President McInnes spoke as follows:

Gentlemen will please come to order. There are no restrictions on the ladies.

First of all, a word to the ladies. In the name of our Association permit me to welcome you most heartily, and to thank you for coming through this horrible weather to be with us to-day. We acknowledge you to be superior beings, and we agree with Burns —

> "Auld nature swears, the lovely dears
> Her noblest work she classes, O:
> Her 'prentice han' she tried on man,
> An' then she made the lassies, O."

Our mistake in the past has been to try to get along too often without the inspiration of your presence. Allow me to ask you to make yourselves thoroughly at home and to enjoy the afternoon.

My next duty is to — no, it would be absurd for me to introduce the speaker. Our Association is very deeply indebted to him already, and we are fortunate indeed that he is willing to increase our obligations. I have very great pleasure in presenting Mr. Desmond FitzGerald.

MR. DESMOND FITZGERALD. *Mr. President, Fellow-Members and Ladies,* — who, according to our President, were made last, that being always the order in the creation of perfect works: I wish to thank you for your very kind introduction and cordial reception. A good many years have now passed since this Association started. I had the pleasure of being present at the birth. As I look back on those days and recall the humble way in which we began, and then look around to-day and see this great Association stretching out like a great tree, with branches in every direction, I can hardly believe my own eyes. The progress of the New England Water Works Association is little short of marvelous. In the beginning, the standards for construction were in process of development and it was due largely to the interesting and instructive discussions before this body that correct practice was more or less standardized. Think for a moment how water-work systems have grown in New England and how much good they have accomplished for the health and prosperity of the people. In this work our Association has played a prominent and important part and I believe you will agree with me that we are entitled to be proud of its growth and success. [*Applause.*]

Mr. FitzGerald then proceeded to show and describe a series of colored lantern slides, the photographs from which they were made having been taken by him. There were views of scenes in this country and in England, France, Switzerland, Italy, and other European countries, and in Japan and the Philippines.

After Mr. FitzGerald had finished, before proceeding with the regular business of the meeting, the President said:

There is present this afternoon a gentleman who has come among us to take a new position of unusual trust and responsibility, — one which he is very well qualified to discharge, — and he has kindly consented to address us. I have the honor to introduce Dr. Allan J. McLaughlin, Commissioner of Health of the State of Massachusetts.

DR. MCLAUGHLIN. *Mr. President and Ladies and Gentlemen,* — I have always been very much interested in the general subject of water. My interest in water extends back for some years, but I am almost ashamed to say how many, in view of the fact that one of your members reminded me that he had been inter-

ested in it since 1872. I said to him that that was the year in which I was born, and he was unkind enough to suggest that at that time I probably was more interested in milk than I was in water.

When I came to Massachusetts I was warned by one of my friends who said, "Above all things keep out of politics. Don't let your former political affiliations hamper you in any way in the work you have to do here." I replied to that, "My friend, I have been an officer of the United States Public Health Service for over fifteen years, and they have kept me moving about so fast that I haven't yet acquired a legal residence anywhere or had an opportunity to exercise the privilege of voting, so I don't even know what my politics are."

I am not prepared to make a speech to-day, and I do not intend to attempt to do it. I would like to say, however, that it gives me great pleasure to come in contact with the engineers and superintendents and others engaged in the water-supply problems of this country. It is a most interesting thing to note the evolution which has taken place in water-supply matters, as in public health matters, and I regard all water-works engineers and all water-works superintendents as health officers. And, ladies and gentlemen, I mean no reflection when I say that. I do not mean that I consider you to be of the old type of health officers who considered their duty done when they tacked a scarlet fever card on the wall. I have never met a poor health officer who was an engineer, and I have known some good health officers who were doctors. More than that I will not say.

I regard the evolution of water supplies as one of the most marvelous stories that could be read, if there were some one really able to put it on paper. I know that at one time the effort of the water-works engineers and of the water boards of the country was to secure a sufficient supply of water. Their next step was to secure a supply which was a good looking supply and which was not offensive to the senses. But it has given me much pleasure to note that it is the rule to-day for water boards and water engineers, especially, to consider that they have an obligation outside of those two former requirements, and that is an obligation to supply safe water. They all recognize it. No

longer are they so much interested in getting out the greatest number of British thermal units from a pound of coal, or in such problems as that, but they now realize that the primary interest of the people of this country is in getting safe water.

There was a time, some years ago, when the problem of a safe water supply was supposed to be solved by the introduction of an up-to-date filter plant, but we have about gotten away from that. We know that the mere installation of a plant does not solve the problem, but that it must be efficiently operated every day in the year. There is an unfortunate tendency still in some places to accept any type of raw water as suitable for purification, and there are filter plants in this country which are struggling with raw waters of such a character that an unreasonable responsibility is placed upon the plant. Water supplies of this type cannot be efficiently operated every day in the year; it is expecting too much. Safe water can be obtained from a filter plant under such conditions only by eternal vigilance, perfect operation, and the free use of chemicals. Plants receiving such raw water are entitled to the benefit of a fair effort to remove sufficient sewage from the water so that the burden will not be too great for the plant to bear.

I know that in Massachusetts and in New England generally the common type of supply is obtained by impounding upland sources and depending upon storage largely as a factor of safety. We all know that that is perfectly safe, provided you have real storage; but I cannot resist the temptation to make this point: That, if you are depending upon storage for the furnishing of safe water, be sure that you get storage. That is a perfectly safe method of water purification, provided the storage is long enough. But there are two things to consider: First, do you get storage for a sufficient number of days to permit the death of the pathogenic organisms which inevitably get into a water supply from an inhabitated surface? And, next, does the position of your inflow and outflow pipes guarantee that your storage is effective? There are some reservoirs built in such a way that sometimes the water goes through from the intake to the outflow pipe without getting the benefit of storage in the reservoir. I have no doubt you have all had experience with just such conditions.

I feel that as a measure of public health there is probably no other single agency that has the potentiality for danger that unsafe water has; and, perhaps, there is no other single measure that has effected so much in the saving of human life in this country as a safe water supply.

The meeting then proceeding with the regular order of business, the Secretary presented the following applications for membership, properly endorsed and recommended by the Executive Committee:

Resident. — P. J. Conlon, North Adams, Mass., superintendent water works, North Adams; Charles R. Gow, West Roxbury, Mass., contractor for public works; Dwight L. Agnew, North Scituate, Mass., assistant superintendent, Scituate Water Company; Harvey A. Bancroft, Reading, Mass., water commissioner; Clarence M. Blair, New Haven, Conn., civil engineer.

Non-Resident. — Frank H. Stephenson, Cleveland, Ohio, superintendent Cleveland water works.

On motion of Mr. Chase, the Secretary was instructed to cast the ballot of the Association in favor of the applicants named, and he having done so they were declared duly elected members of the Association.

The Secretary, Mr. Willard Kent, presented his annual report, as follows:

Report of the Secretary.

January 1, 1915.

Mr. President and Gentlemen of the New England Water Works Association, — The Secretary submits herewith the following report of the changes in membership during the past year, and the general condition of the Association.

The present membership is 847, constituted as follows: 11 Honorary, 766 Active, and 70 Associate members. That of one year ago was 758, comprised of 12 Honorary, 686 Active, and 60 Associate members. A net gain for the year of 89. The detailed changes are as follows:

MEMBERSHIP.

January 1, 1914.	Honorary Members	12	
	Deceased	1	
		—	11

January 1, 1914.	Total Members		686		
	Withdrawals:				
	Resigned	21			
	Dropped	34			
	Died	5	60		
		—	—	626	
	Initiations:				
	January	7			
	February	1			
	March	3			
	April	12			
	June	4			
	September	40			
	November	19			
	December	17			
		—	103		
	Reinstated:				
	Members dropped in '02	2			
	" " " '05	1			
	" " " '11	3			
	" " " '13	1			
	" " " '14	27			
	" resigned in '04	1			
	" " " '08	1			
	" " " '14	1	37	140	
		—	—	—	766
January 1, 1914.	Total Associates		60		
	Withdrawals:				
	Dropped	2			
	Resigned	5	7		
		—	—	53	
	Initiations:				
	June	1			
	September	12			
	November	3			
		—	16		
	Reinstated:				
	Dropped in 1914		1	17	
			—	—	70
January 1, 1915.	Total membership				847
January 1, 1914.	Total membership				758
	Net gain				89

The Secretary has received and paid to the Treasurer, $7 469.64.

Of this amount the

Receipts for initiation fees were			$619.00
From dues of members	$2 121.00		
From dues of members, fractional	78.00		
From dues of members, past	18.00		
		$2 217.00	
From dues of Associates	$790.00		
From dues of Associates, fractional	106.25	896.25	
Total from dues			3 113.25
From advertising			1 988.25
From subscriptions			243.00
From JOURNALS			214.44
From sundries			1 291.70
Total as above			$7 469.64

There is due the Association at this date:

For advertising	$113.75
For JOURNALS	47.00
For reprints	17.10
Total amount due	$177.85

The outstanding bills against the Association amount to $104.95.

Respectfully submitted,

WILLARD KENT, *Secretary.*

Year	President.	Membership at End of Year.				Annual Convention.		Receipts.	Expenditures.	Cash Balance.
		Members.	Associate.	Honorary.	Total.	Place.	Date.			
1882	(Organized)	27	—	—	27	Boston, Mass.	June 21, '82			
1882–3	*James W. Lyon	37	6	—	43	Worcester, Mass.	June 21, '83	$245.00	$87.86	$157.14
1883–4	Frank E. Hall	48	9	—	57	Lowell, Mass.	June 19–20, '84	156.14	171.90	141.38
1884–5	*George A. Ellis	83	44	—	127	Springfield, Mass.	June 18–19, '85	651.84	511.44	281.78
1885–6	R. C. P. Coggeshall	106	47	—	153	New Bedford, Mass.	June 16–18, '86	1 658.50	1 643.42	296.86
1886–7	*Henry W. Rogers	137	52	2	191	Manchester, N. H.	June 15–17, '87	1 342.28	1 066.98	572.16
1887–8	*Edwin Darling	181	54	3	238	Providence, R. I.	June 13–15, '88	2 013.30	1 697.15	888.31
1888–9	*Hiram Nevons	209	64	4	277	Fall River, Mass.	June 12–14, '89	2 204.07	2 127.70	964.68
1889–90	Dexter Brackett	257	73	5	335	Portland, Me.	June 11–13, '90	2 511.27	2 346.65	1 129.30
1890–1	*Albert F. Noyes	281	74	5	360	Hartford, Conn.	June 10–12, '91	3 055.13	1 884.78	2 299.65
1891–2	*Horace G. Holden	290	70	5	365	Holyoke, Mass.	June 8–10, '92	2 887.17	3 278.54	1 908.28
1892–3	*George F. Chace	338	69	5	412	Worcester, Mass.	June 14–16, '93	3 422.61	3 317.22	2 013.67
1893–4	*Geo. E. Batchelder	365	73	5	443	Boston, Mass.	June 14–16, '94	3 208.85	3 259.07	1 963.45
1894–5	George A. Stacy	401	81	5	487	Burlington, Vt.	Sept. 11–13, '95	3 147.41	3 115.99	2 673.03
1895–6	Desmond FitzGerald	442	82	5	529	Lynn, Mass.	June 10–12, '96	3 179.91	3 148.49	2 704.45
1896–7	*John C. Haskell	464	80	5	549	Newport, R. I.	Sept. 8–10, '97	3 340.23	3 322.94	2 271.74
1897–8	Willard Kent	488	77	5	570	Portsmouth, N. H.	Sept. 14–16, '98	3 002.13	2 786.95	2 936.92
1898–9	Fayette F. Forbes	494	73	5	572	Syracuse, N. Y.	Sept. 13–15, '99	2 825.71	3 050.23	2 712.40
1899–1900	Byron I. Cook	519	70	5	594	Rutland, Vt.	Sept. 19–20, '00	4 920.49	5 524.65	2 108.24
1901	Frank H. Crandall	493	58	4	555	Portland, Me.	Sept. 18–20, '01	4 238.55	4 283.22	2 063.57
1902	Frank E. Merrill	522	60	5	587	Boston, Mass.	Sept. 10–12, '02	5 158.48	4 680.32	2 541.73
1903	*Charles K. Walker	520	55	3	586	Montreal, Canada	Sept. 9–11, '03	5 032.40	4 505.08	3 069.05
1904	Edwin C. Brooks	538	58	8	604	Holyoke, Mass.	Sept. 14–16, '04	5 328.31	5 528.21	2 869.15
1905	George Bowers	584	53	8	645	New York, N. Y.	Sept. 13–16, '05	5 431.16	5 411.58	2 888.73
1906	Wm. T. Sedgwick	618	51	15	684	White Mts., N. H.	Sept. 12–14, '06	5 366.94	4 845.14	3 410.53
1907	John C. Whitney	636	51	15	692	Springfield, Mass.	Sept. 11–13, '07	5 291.83	†4 222.06	4 480.30
1908	Alfred E. Martin	633	49	14	696	Atlantic City, N. J.	Sept. 23–25, '08	5 706.36	7 475.56	‡2 711.10
1909	Robert J. Thomas	647	55	13	715	New York, N. Y.	Sept. 8–10, '09	5 305.31	†4 566.84	‡3 449 57
1910	George A. King	678	56	13	747	Rochester, N. Y.	Sept. 21–23, '10	6 507.08	†7 237.60	‡2 719.05
1911	Allen Hazen	680	58	12	750	Gloucester, Mass.	Sept. 13–15, '11	6 440.90	†6 279.72	‡2 880.23
1912	Geo. W. Batchelder	666	53	12	731	Washington, D. C.	Sept. 18–20, '12	6 861.65	†5 934.56	‡3 807.32
1913	J. Waldo Smith	686	60	12	758	Philadelphia, Pa.	Sept. 10–12, '13	6 122.81	†6 533.62	‡3 396.51
1914	Frank A. McInnes	766	70	11	847	Boston, Mass.	Sept. 9–11, '14	7 686.17	†7 437.17	‡3 645.51

*Deceased. † Not including December Journal and Reprints. ‡ Does not include $1 815 invested in bonds.

On motion the report was accepted.

The Treasurer, Mr. Lewis M. Bancroft, submitted the following report, which on motion of Mr. Sherman was accepted and ordered to be placed on file.

CLASSIFICATION OF RECEIPTS AND EXPENDITURES.

Receipts.

Dividends and interest		$221.23
Initiation fees	$619.00	
Dues	3 113.25	
Total received from members		3 732.25
JOURNAL:		
Advertisements	$1 988.25	
Subscriptions	243.00	
Sale of JOURNALS	214.44	
Sale of Reprints	100.35	
Total received from JOURNAL		2 546.04
Miscellaneous receipts:		
Sale of "Pipe Specifications"	$42.80	
Dinners	1 035.00	
Certificates of membership	99.00	
Buttons, etc.	9.85	
Total miscellaneous receipts		1 186.65
Total receipts		$7 686.17

Expenditures.

JOURNAL:		
Advertising agent, commission	$239.00	
Plates	141.57	
Printing	2 019.03	
Editor's salary	300.00	
Expense	42.77	
Reporting	280.45	
Advance reports	90.00	
Reprints	253.00	
Envelopes	35.15	
		$3 400.97

LEWIS M. BANCROFT, *Treasurer*,
In account with the New England Water Works Association.

RECEIPTS.			EXPENDITURES.		
1914.					
Jan. 1.	Balance on hand	$3 396.51	Bills paid		$7 437.17
	Received of Willard Kent, Secretary	7 469.64	BALANCE ON HAND.		
	Interest on bonds and deposits	216.53	People's Savings Bank	$2 000.00	
			Mechanics Savings Bank	1 098.60	
			First National Bank	529.90	
			Liberty Trust Co.	17.01	
					3 645.51
		$11 082.68			$11 082.68

ASSETS AND LIABILITIES.

ASSETS.			LIABILITIES.		
Cash, balance in banks		$3 645.51	Accounts payable:		
Bonds Nos. 2642 and 2644, Lake Shore & Mich. So. R. R. 4%, due May 1, 1931. Book value, $1 815. Market value		1 800.00	Rent		$100.00
			Blue prints		4.95
Accounts receivable:					$104.95
JOURNALS	$47.00		Surplus		5 518.41
Advertising	113.75				
Reprints	17.10				
		177.85			
		$5 623.36			$5 623.36

READING, January 11, 1915.

LEWIS M. BANCROFT, *Treasurer*.

Office:			
Secretary, salary		$200.00	
Expense		50.50	
Assistant Secretary, salary		600.00	
Expense		194.10	
Rent		400.00	
Printing, stationery, and postage		221.75	
Membership lists		202.00	
Miscellaneous		17.61	
			$1 885.96
Meetings and Committees:			
Stereopticon		$40.00	
Dinners	$1 020.50		
Cigars	58.00		
Music	109.60		
		1 188.10	
Printing, stationery, and postage		579.58	
Miscellaneous		32.31	
Negatives		35.70	
Street railway, June meeting		25.00	
			1 900.69
Treasurer's salary and bond			67.50
Library Index			29.30
Certificates of membership			125.25
Printing "Pipe Specifications"			27.50
			$7 437.17

The Editor, Mr. Richard K. Hale, submitted the following report:

Report of the Editor.

Boston, January 13, 1915.

To the New England Water Works Association, — I present the following report for the Journal of the New England Water Works Association for the year 1914.

The accompanying tabulated statements show in detail the amount of material in the Journal; the receipts and expenditures on account of the Journal for the past year (including the cost of the December Journal and reprints, bills for which were received too late to pay in 1914, and which are consequently not included in the Treasurer's statement); and a comparison with the conditions of preceding years.

Size of Volume. — The volume is somewhat larger than in previous years.

Illustrations. — The total cost of illustrations for the year, including printing, has been $221.87, or 6.6 per cent. of the gross cost of the volume.

Reprints. — The usual fifty reprints of papers have been furnished to authors without charge, and additional reprints, when desired, at the cost of the paper and press work. The net cost to the Association for reprints has been $155.65. There have been advance copies of eight papers prepared during the year, at a cost of $108.00.

Circulation. — The present circulation of the JOURNAL is:

Members, all grades	847
Subscribers	78
Exchanges	26
Total	951

an increase of 93 over the preceding year. JOURNALS have also been sent to 40 advertisers.

Advertisements. — There has been an average of 25 pages of paid advertising, with an income of $1 694, a slight increase over last year.

Pipe Specifications. — During the year the specifications for cast-iron pipe to the value of $42.80 have been sold; 500 were printed at a cost of $27.50. The net gain up to a year ago had been $258.75, so that the total net gain from this source to date is $274.05. There are still about 438 copies of specifications on hand, or about $44.00 worth if sold at retail.

The Association has a credit of $0.61 at the Boston Post-Office, being the balance of the money deposited for payment of postage upon the JOURNAL at pound rates.

There are no outstanding bills on account of the JOURNAL, which are not included in these tables.

Respectfully submitted,

RICHARD K. HALE, *Editor.*

TABLE No. 1.

STATEMENT OF MATERIAL IN VOLUME XXVIII, JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION, 1914.

Number.	Date.	Pages of								Total Cuts.
		Papers.	Proceedings.	Total Text.	Index.	Advertisements.	Cover and Contents.	Inset Plates.	Total.	
1	March	77	35	112	—	29	4	3	148	10
2	June	79	7	86	—	30	4	—	120	11
3	September	140	18	158	—	30	4	—	192	13
4	December	199	9	208	7	30	4	10	259	21
	Total	495	69	564	7	119	16	13	719	55

TABLE No. 2.

RECEIPTS AND EXPENDITURES ON ACCOUNT OF VOLUME XXVIII, JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION, 1914.

Receipts.		*Expenditures.*	
Advertisements	$1 693.75	Printing JOURNAL	$1 987.64
Sale of JOURNAL	214.44	Printing illustrations	85.00
Sale of reprints	39.35	Preparing illustrations	136.81
Subscriptions	243.00	Editor's salary	300.00
	$2 190.54	Editor's incidentals	44.17
Net cost of JOURNAL	1 155.33	Advertising agent's commissions	235.05
		Reporting	254.20
		Reprints	195.00
		Advance copies	108.00
	$3 345.87		$3 345.87

TABLE No. 3.

Comparison between Volumes XIX to XXVIII, Inclusive, Journal of the New England Water Works Association.

	Vol. XIX. 1905.	Vol. XX. 1906.	Vol. XXI. 1907.	Vol. XXII. 1908.	Vol. XXIII. 1909.	Vol. XXIV. 1910.	Vol. XXV. 1911.	Vol. XXVI. 1912.	Vol. XXVII. 1913.	Vol. XXVIII. 1914.
Average edition (copies printed)	900	900	1 085	1 000	1 000	1 150	1 000	1 000	1 000	1 050
Average membership	625	665	693	699	710	732	752	740	745	803
Circulation at end of year	705	767	785	780	802	827	840	826	858	951
Pages of text	587	495	500	500	459	643	475	401	554	564
Pages of text per 1 000 members	939	745	722	715	646	880	632	542	746	702
Total pages, all kinds	784	662	669	681	627	808	654	567	733	719
Total pages per 1 000 members	1 254	995	964	976	884	1 090	870	766	984	895
Gross Cost:										
Total	$3 266.65	$2 573.61	$2 643.42	$2 733.61	$3 111.15	$3 490.81	$2 625.87	$2 476.55	$3 586.29	$3 345.87
Per page	4.17	3.88	3.95	4.01	4.97	4.32	4.02	4.37	4.89	4.65
Per member	5.23	3.87	3.82	3.91	4.39	4.78	3.50	3.35	4.81	4.17
Per member per 1 000 pages	6.67	5.85	5.70	5.88	7.00	5.90	4.09	5.90	6.46	5.80
Per member per 1 000 pp. text	8.91	7.81	7.62	8.02	9.56	7.44	7.36	8.35	8.68	7.39
Net Cost.										
Total	$1 072.95	$387.96	$483.15	$131.06	$789.98	$1 334.06	$352.82	$98.81	$1 322.90	$1 155.33
Per page	1.37	.58	.72	.19	1.26	1.65	.54	.17	1.80	1.61
Per member	1.72	.58	.70	.19	1.11	1.82	.47	.13	1.78	1.44
Per member per 1 000 pages	2.20	.88	1.04	.28	1.78	2.25	.55	.23	2.42	2.00
Per member per 1 000 pp. text	2.93	1.18	1.39	.39	2.43	2.83	.98	.33	2.38	2.55

The report was accepted.

The Auditing Committee submitted the following report:

BOSTON, MASS., January 11, 1915.

We have examined the accounts of the Secretary and Treasurer of the New England Water Works Association, and find the books correctly kept and the various expenditures of the past year supported by duly approved vouchers.

Respectfully submitted,

GEORGE H. FINNERAN,
FREDERICK W. GOW,
A. R. HATHAWAY,
Auditing Committee.

On motion of Mr. Sherman, the report of the Auditing Committee was accepted.

Professor George C. Whipple, chairman of the Committee on Filter Statistics, reported that the committee had finished its labors and made its report, which was before the Association. As this was not the time to discuss it, he suggested that it be laid over until the February meeting of the Association, and on motion such action was taken.

Mr. McInnes, the retiring President, then read his annual address.

PRESIDENT'S ADDRESS.

It is difficult to realize that one year has elapsed since my duties as President of this Association began. Thomas Campbell, in inimitable verse, says, "The more we live, more brief appear our life's succeeding stages." This statement of fact does not, however, fully account for the rush with which the past year has become history, and it is gratifying, at least to assume, that the apparent speed of Father Time has been due to the activity and vitality of our Association.

Somewhat of fear and trembling possessed me at the outset; fear that my inexperience would prove a serious handicap, and trembling, on general principles, at I knew not what. I can now say — What a fool one mortal was! — and why? — simply because he did not fully realize the meaning of the magic word

"coöperation," despite the fact that our last President had, in his annual address, so convincingly and forcibly called attention to the possibilities of "working together." As a matter of fact, the hearty coöperation of our members, — officers, privates, and associates alike, — has made my path an easy one and has caused whatever measure of success has been attained.

In the reports of the Secretary, Treasurer, and Editor, which have been read this afternoon, you have heard the story of our affairs in detail for the year. The Treasurer has been good enough to show a balance on the right side of the ledger. The net gain in membership of 89, in this year of hard times when business depression is widespread and the dogs of war are loose, is the largest in the history of our Association; it is due to the splendid coöperation of which I have spoken.

Six regular meetings were held, each being well attended and of normal interest. I am convinced that these meetings can be made of still greater value to our members. A strict censorship should be exercised over the papers which are presented, to correct the condition we have all witnessed of inattention of a portion of the audience. Many papers can be read verbatim to advantage; others, often of the greatest value, should be presented in abstract form with those portions omitted which are not of direct interest to the audience as a whole, and which must be carefully read and studied at a later date in our JOURNAL if their full value is to be realized. In this way the opportunity of meeting and questioning the author would be afforded and the purposes of full and free discussion would still be served.

Another desirable feature at our meetings is, that at least a portion of the time be devoted to the subjects in which our active members are directly interested and with which they have to do in their every-day work, to the end that the experience gained from the methods, successes, failures, difficulties, etc., of each one of us may be available for all. This give-and-take spirit of helping each other must be strongly in evidence if our meetings are to be of maximum benefit and interest.

I realize that a large majority of members are unable to attend the regular meetings, and appreciate the fact that the character of the papers and reports which are published in the JOURNAL,

many of them classics in their field, has proved a large factor in the present prestige and success of our Association; this high standard of the past must be and will be maintained, for the willingness of our members to give of their ability and of their store of knowledge is, at least, as strong as ever.

The best traditions of our Association have been maintained in the work of our committees; at the November meeting the report of the Committee on Standard Specifications for Hydrants was considered and adopted with the exception of two requirements which were referred back to the committee for further consideration. At the annual convention three notable reports were presented, as follows: On Low Yields of Catchment Areas in New England, F. P. Stearns, chairman; on Statistics of Filter Operations, George C. Whipple, chairman; on Meter Rates, Allen Hazen, chairman.

In June, thanks to a very efficient committee, a most enjoyable outing was held at Worcester; an interesting trip over the new supply works of the city being followed by dinner on a tiny and picturesque island in Lake Quinsigamond. Such an outing, in the early summer, with the ladies participating, does much to promote good-fellowship.

The annual convention at the Copley-Plaza Hotel in this city was successful; the attendance, at least, surpassing all previous records; the Association is deeply indebted to the committees in charge.

The convention is a most effective means of furthering the interests of our Association; to be successful, in this age in which we live, suitable entertainment must be provided, at least for the ladies in attendance; the question of how the funds necessary for this purpose shall be obtained must be solved in a permanent way.

Perpetual motion has not yet been discovered; force is still required to produce results, and our Association must receive the active, continuous support of its officers and members alike if it is to be of the greatest service and is to consistently grow in strength. We must have scholarly, able, and adequate papers; interesting and practical discussions; committee reports strong enough to guide us in the right channels; good-fellowship, and

an abounding faith in our Association. We must not live in the past but, realizing that conditions and customs surrounding us are ever changing, must move, with conservative steps, in the vanguard.

Mr. Thomas E. Lally submitted the following report of tellers appointed to canvass ballots for the officers for the coming year.

ELECTION OF OFFICERS.

Whole number of ballots	353
Blank	None

President.

LEONARD METCALF	342
Scattering	1

Vice-President.

JAMES BURNIE	337
CARLETON E. DAVIS	341
GEORGE F. MERRILL	336
CALEB M. SAVILLE	338
CHARLES W. SHERMAN	342
WILLIAM F. SULLIVAN	342
Scattering	1

Secretary.

WILLARD KENT	346
Scattering	1

Treasurer.

LEWIS M. BANCROFT	345

Editor.

RICHARD K. HALE	346

Advertising Agent.

GEORGE A. KING	345
Scattering	1

Additional Members of Executive Committee.

EDWIN C. BROOKS	336
SAMUEL E. KILLAM	337
GEORGE W. BATCHELDER	340

Finance Committee.

A. R. Hathaway..... 339
George H. Finneran..... 337
Albert L. Sawyer..... 341
Scattering..... 1

Respectfully submitted,

THOMAS E. LALLY.
LEWIS D. THORPE.

On motion of Mr. Sherman it was voted to adjourn.

Hotel Brunswick,
Boston, Mass., February 10, 1915.

Vice-President William F. Sullivan in the chair.
The following members and guests were present:

Honorary Members.

Frederic P. Stearns. — 1

Members.

D. L. Agnew, L. M. Bancroft, G. W. Batchelder, A. E. Blackmer, J. W. Blackmer, George Bowers, E. C. Brooks, J. M. Caird, G. A. Carpenter, J. C. Chase, R. C. P. Coggeshall, R. D. Chase, F. L. Clapp, H. W. Clark, J. E. Conley, A. W. Cuddeback, H. C. Crowell, F. W. Dean, J. M. Diven, E. D. Eldredge, G. F. Evans, A. A. Fobes, G. W. Fuller, H. T. Gidley, Patrick Gear, F. J. Gifford, A. S. Glover, J. M. Goodell, X. H. Goodnough, F. H. Gunther, R. A. Hale, R. K. Hale, F. E. Hall, J. O. Hall, A. R. Hathaway, T. G. Hazard, Jr., Allen Hazen, D. A. Heffernan, D. J. Higgins, J. L. Howard, A. C. Howes, W. S. Johnson, Willard Kent, S. E. Killam, G. A. King, J. J. Kirkpatrick, E. E. Lochridge, P. J. Lucey, Hugh McLean, A. E. Martin, H. W. McMahon, John Mayo, G. F. Merrill, H. A. Miller, A. S. Negus, F. L. Northrop, T. A. Peirce, L. C. Robinson, G. A. Sampson, P. R. Sanders, A. L. Sawyer, W. P. Schwabe, J. E. Sheldon, Carleton Scott, C. W. Sherman, M. A. Sinclair, G. H. Snell, G. T. Staples, W. F. Sullivan, H. A. Symonds, W. C. Tannatt, Jr., C. N. Taylor, R. J. Thomas, J. L. Tighe, A. H. Tillson, E. J. Titcomb, D. N. Tower, W. J. Turnbull, Ernest Wadsworth, R. S. Weston, G. C. Whipple, F. B. Wilkins, L. C. Wright. — 83.

Associates.

Builders Foundry Company, by F. N. Connet and A. B. Coulters; Chapman Valve Manufacturing Company, by J. F. Mulgrew and J. J. Hartigan; Darling Pump and Manufacturing Company (Ltd.), by H. A. Snyder; Gamon

Meter Company, by J. S. Eggert; Hayes Machinery Company, by F. H. Hayes; Hersey Manufacturing Company, by A. S. Glover, W. A. Hersey, and S. B. Greene; Lead Lined Iron Pipe Company, by T. E. Dwyer; Ludlow Valve Manufacturing Company, by A. R. Taylor; G. A. Miller; H. Mueller Manufacturing Company, by G. A. Caldwell; National Meter Company, by J. G. Lufkin and H. L. Weston; Neptune Meter Company by R. D. Wertz and H. H. Kinsey; Norwood Engineering Company by H. W. Hosford; Pittsburgh Meter Company, by J. W. Turner; MacBee Cement Lined Pipe Company, by J. D. MacBride; Rensselaer Valve Company, by C. L. Brown; A. P. Smith Manufacturing Company, by F. L. Northrop; Thomson Meter Company, by S. D. Higley and E. M. Shedd; Union Water Meter Company, by F. E. Hall; Water Works Equipment Company, by W. H. VanWinkle; R. D. Wood & Co., by H. M. Simmons; Henry R. Worthington, by Samuel Harrison, E. P. Howard, and W. T. Bird. — 31.

GUESTS.

DeWitt C. Webb, F. M. Bates, H. C. Bond, Boston, Mass.; G. F. Goldthwait, Beverly; G. E. Hildreth, Manchester; G. H. Hiller, Hyde Park; W. F. Howland, South Framingham; H. J. Goodale, Attleboro; F. M. Sears, Northampton; E. S. Russell, Middleboro, Mass.; B. E. Warren, Nashua, N. H.; H. A. Rowell, Concord, N. H.; Edward W. Shedd, Providence, R. I.; E. S. Locke, Lexington, Mass. — 14.

The Secretary presented the following applications for membership, properly endorsed and recommended by the Executive Committee: John E. Howland, Vineyard Haven, Mass., machinist, manufacturing photographic apparatus; Carl P. Birkinbine, Philadelphia, Pa., investigations, reports, and construction of water supply and water power, dam design, water waste; Stuart A. Nims, Concord, N. H., engineer for New Hampshire Public Service Commission; Edward W. Shedd, East Providence, R. I., civil, sanitary, and hydraulic engineer; H. J. Goodale, Attleboro, Mass., assistant engineer Board of Public Works, Pittsfield, superintendent public works, Attleboro, Mass.

On motion, the Secretary was directed to cast the ballot of the Association in favor of the applicants, and he having done so they were declared duly elected members of the Association.

The Secretary read a communication from Mr. George T. Staples, as follows:

DEDHAM, MASS., February 2, 1915.

EXECUTIVE COMMITTEE,
NEW ENGLAND WATER WORKS ASSOCIATION:

Gentlemen, — In looking over the list of members, I find that Mr. R. W. Bagnell, Mr. R. C. P. Coggeshall, Mr. Albert S. Glover, and Mr. Frank E. Hall have been members of the New England Water Works Association since June 21, 1882, — charter members probably.

If it meets with your approval, I would make a motion that they be made honorary members and added to the Executive Committee.

Yours truly,

GEORGE T. STAPLES.

THE SECRETARY. This letter, so far as making the parties named honorary members, has been considered by the Executive Committee and they recommend to the Association that such action be taken.

THE CHAIRMAN. The letter is self-explanatory, evidently showing that we have a quartet of charter members still on full membership roll.

MR. R. C. P. COGGESHALL. Mr. President, I do not understand what all this means. I don't want my obituary notice written quite yet. It is pleasant to know that my friends think of me once in a while, but I am getting along pretty comfortably just as it is.

MR. FRANK E. HALL. Mr. President, I endorse everything that Mr. Coggeshall has said.

MR. FREDERIC P. STEARNS. Mr. President, in regard to writing an obituary, I can say, as one of the men who has been made an honorary member of this Society, that they are still allowed to do some work. I move that the recommendation of Mr. Staples be adopted.

MR. C. W. SHERMAN. Mr. President, I believe that any election to membership has to be made by ballot, and if Mr. Stearns will allow me, I would like to amend his motion to the effect that the Secretary be instructed to cast the ballot of the Association for these four gentlemen named in Mr. Staples's letter and that the vote on this motion be taken by a rising vote. [Adopted, the the members all rising.]

MR. COGGESHALL. Mr. President, do I understand that that was announced as carried?

THE CHAIRMAN. It is carried, and I declare those four gentlemen elected honorary members of the New England Water Works Association.

MR. COGGESHALL. Gentlemen, I feel funny. This is very gratifying. I am pleased and I am delighted to know that there are so many kindly feelings towards me. I well remember the day in February of 1882 when Mr. Hall and myself went to Bob Thomas's home at Lowell, and in the Merrimac House of that city we suggested the formation of a little club to meet once a month, perhaps in Boston, during the winter months, and discuss water-works matters. But we never dreamed of an association of eight hundred members. It has gone so far beyond our expectation that sometimes I am bewildered when I look back and see that day. It reminds me that I am getting along in years. I suppose that a great many of you regard me as an old man, but I want to tell you that I am coming here for the next twenty-five years. I want to heartily thank you, gentlemen. I do, from the bottom of my heart.

THE CHAIRMAN. You might have noticed that in his letter Mr. Staples asked that these gentlemen be added to the Executive Committee. As that would require a notice to the members and a change in our by-laws, the Executive Committee thought better to drop that portion of it.

MR. F. H. HAYES. Mr. President, this is a paper that I would like to bring before this Association. It will tell what it is as I read it:

"What I have to say at this time is a diversion from that which is to interest us at this meeting.

"It is a condition that comes many times to the associate members of this Association, and, it may be possible, may not interest the other members as it does the associate members.

"It is the general custom whenever proposals are asked for pumping machinery, and other material that is used in connection with water works, that a certified check is asked for. This check varies in amount from one hundred dollars to five thousand dollars. At the time such a check is certified to by any bank, it is immediately charged against the account of the bidder, and in such action makes whatever the amount of the check may be just so much dormant money. I have personally known of many places where more than twenty-five thousand dollars were so affected for a number of weeks.

"I think that we all know that to make money, money must be kept in

circulation; also there is another condition that is possible to arise, — that after a check has been certified and passed along, a bank may be placed in a position where it cannot honor the check, either for the purchaser or the bidder. If such a condition should arise, then the use for which such certified check was given is voided and its value doubtful and would be an affliction to the one that gave the check.

"To overcome the stopping of circulation of money occasioned by the use of certified checks, and to show a way to accomplish the purpose of the certified check, it is suggested that, in the place of a certified check, a bond issued by any of the responsible bond companies be accepted.

"This is the common custom which the United States Government accepts with proposals made to them, and our thought is, if it be correct for the government proposals, then it should be for your requirements.

"The object in bringing this subject before this meeting is to have it placed on the minutes of this meeting, so that the subject may be given consideration by the Association, and also to try and get an expression of opinions, both from the members of this Association and its associate members, and at such a time as it may be fully discussed, and I trust that the result will be that that which has been suggested may soon become the general custom.

"F. H. Hayes, *Associate Member.*"

In addition to that, I have before me a paper that was issued December 10, which came back into my hands February 2. It represented an amount of five thousand dollars divided among five different bidders. This came back to me; I wasn't the successful bidder. I thank you, gentleman.

The Chairman. This matter was considered in the Executive Committee to-day, and it is recommended by the Executive Committee that a committee be appointed to consider this matter and report at some subsequent meeting.

Mr. William S. Johnson. Mr. President, considerable time has been devoted for two recent meetings of this Association to the subject of service pipes, and this is only a continuation of the discussion which has been going on for many years. We have arrived at the same place where we have always arrived. We know that Mr. A uses cement-lined service pipe — he thinks that is the only thing for his conditions and will use nothing else; Mr. B uses lead pipe and thinks it is the only thing for his conditions, and Mr. C. something else; and Mr. D wants tin-lined pipe used.

Now, there are a number of us who do not have a chance to experiment, and we have to recommend what service pipe shall be used in the new systems. I believe there is some reason why

at Brookline they thought cement-lined pipe the only pipe to use, and in another place lead pipe is considered the best. I believe it is perfectly possible to determine what those reasons are, and to give them to the Association.

It seems to me that this is one of the best fields that can be covered by a committee of this Association,— such a committee not only to get statistics; we want something more. We want to know why these things are so different in different places, so that we may be able to determine more nearly in advance what will be the most satisfactory material to use. I would recommend, therefore, that a committee of five be appointed by the chair to consider the whole subject of service pipes and to report at some future meeting. I would make that broad enough, and I think that motion is broad enough, so that it would cover also the question of rigid connections versus goose-necks. [Adopted.]

Discussions on reports of committees were then commenced, the first report being on "Yield of Drainage Areas." The discussion was opened by X. H. Goodnough, chief engineer Massachusetts State Board of Health, who read a paper and replied to a question by Mr. William S. Johnson. Mr. Fuller and Mr. Frederic P. Stearns also spoke on the subject.

The paper on "Meter Rates," which was read by Mr. Allen Hazen, chairman of committee, at the September meeting, was discussed by Mr. Albert E. Lochridge, chief engineer of the Springfield Water Works; Mr. C. W. Sherman, who also read a paper by Mr. Philander Betts, a member of the committee; Mr. D. A. Heffernan; Mr. R. D. Chase, who read figures prepared by Mr. Frank J. Gifford, of Fall River; Mr. W. C. Tannatt, Jr., of Easthampton; Mr. Hugh McLean; Mr. C. N. Taylor; Mr. Henry A. Symonds; Mr. F. L. Clapp; Mr. William F. Sullivan; Mr. Willard Kent; Mr. Walter P. Schwabe; Mr. Francis W. Dean, and Mr. F. N. Connet. Mr. Tighe read a paper by Mr. Morris Knowles, consulting engineer, Pittsburg, Pa. The discussion was closed by Mr. Allen Hazen, chairman of committee.

On motion of Mr. George C. Whipple, it was voted that the discussion of the report of committee on "Filter Statistics" be deferred to the next meeting of the Association.

Adjourned.

EXECUTIVE COMMITTEE.

Meeting of the Executive Committee of the New England Water Works Association at headquarters, Tremont Temple, Boston, Mass., Wednesday, January 13, 1915, at 11 o'clock A.M.

Present: President Frank A. McInnes, and members William F. Sullivan, Samuel E. Killam, Richard K. Hale, Lewis M. Bancroft, and Willard Kent.

Applications for membership were received from Patrick J. Conlon, superintendent water works, North Adams, Mass.; Charles R. Gow, contractor for public works, West Roxbury, Mass.; Dwight L. Agnew, assistant superintendent Scituate Water Company, North Scituate, Mass.; Harvey A. Bancroft, water commissioner, Reading, Mass.; Clarence M. Blair, consulting engineer, New Haven, Conn.; Frank H. Stephenson, civil engineer, Cleveland, Ohio; H. J. Croughwell, clerk, Commission of Public Works, Peabody, Mass.; and they were by unanimous vote recommended therefor.

Adjourned.

WILLARD KENT, *Secretary.*

Meeting of the Executive Committee of the New England Water Works Association at headquarters, Tremont Temple, Boston, Mass., February 10, 1915.

Present: William F. Sullivan, George F. Merrill, Charles W. Sherman, Edwin C. Brooks, Samuel E. Killam, George W. Batchelder, Richard K. Hale, Lewis M. Bancroft, George A. King, and Willard Kent, Vice-President William F. Sullivan presiding.

Five applications for membership were received and recommended therefor, viz.:

Stuart A. Nims, engineer New Hampshire Public Service Commission, Concord, N. H.; John E. Howland, treasurer Tisbury Water Works, Vineyard Haven, Mass.; H. J. Goodale, superintendent public works, Attleboro, Mass.; Edward W. Shedd, consulting engineer, Providence, R. I.; Carl P. Birkinbine, hydraulic engineer, Philadelphia, Pa.

Voted, that Messrs. R. C. P. Coggeshall, Frank E. Hall, Albert S. Glover, and Richard W. Bagnell, charter members of the Association, be recommended to the Association for honorary membership.

Voted, on motion of Mr. Sherman, that the question of place of holding the next annual convention be referred to the next meeting of the Executive Committee and that the Secretary be instructed to notify each member of the Executive Committee of this action and invite Mr. Frank A. McInnes to be present.

On motion of Mr. Sherman, it was voted that initiation fees be remitted to members and associates of the American Water Works Association applying for admission to the New England Water Works Association during the year 1915.

The Secretary presented certificate of renewal of treasurer's bond and it was by unanimous vote approved.

Voted, that the President be and hereby is authorized to appoint a committee on papers and such other committees as he may deem necessary for special investigations.

At the request of President Metcalf, Vice-President Charles W. Sherman was authorized to approve bills and countersign checks in the absence of the President.

Voted, that it is inexpedient to take any action relative to the metric system at the present time.

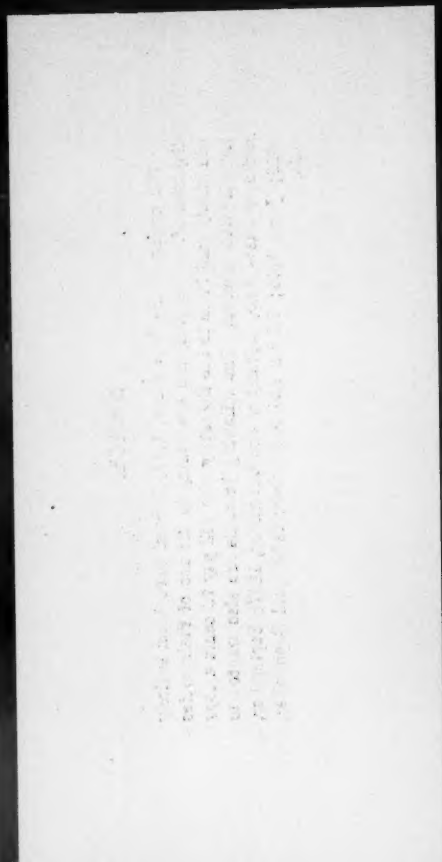
At the suggestion of President Metcalf, that a committee be appointed to prepare an estimate of the receipts and expenses of the Association for the ensuing year, on motion of Mr. Merrill, the President, Secretary, Treasurer, Editor, and Advertising Agent were constituted that committee and instructed to report at the March meeting of the Executive Committee.

Adjourned.

Attest: WILLARD KENT, *Secretary.*

NOTICE.

The copies of the September, 1914, Journal have been entirely disposed of. Members who are willing to dispose of their copies will kindly mail them to the Secretary who will pay 75 cents a copy for a limited number. The following Journals are also wanted to make up sets: June, September and December, 1887; September, 1888; June, 1893; March and September, 1899; and September, 1905.



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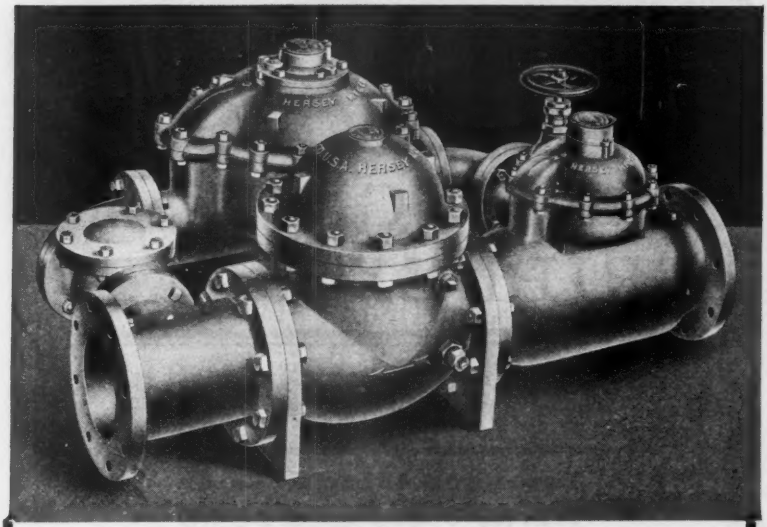

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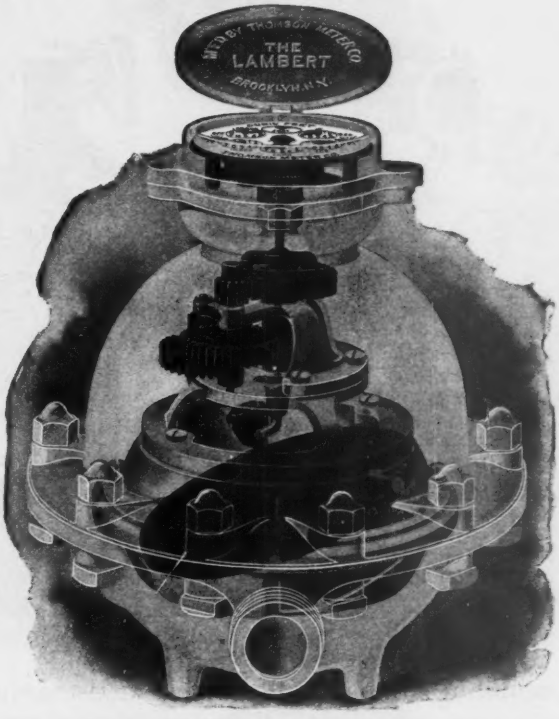

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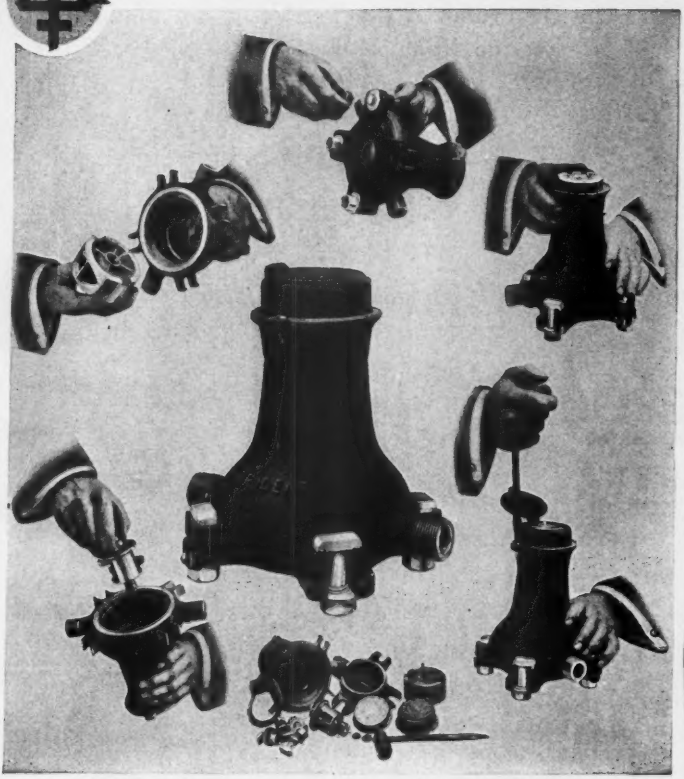

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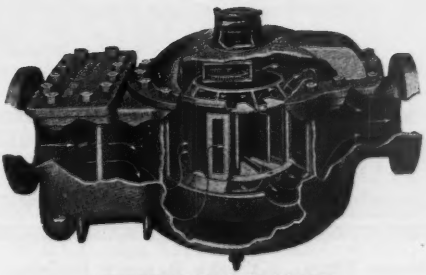

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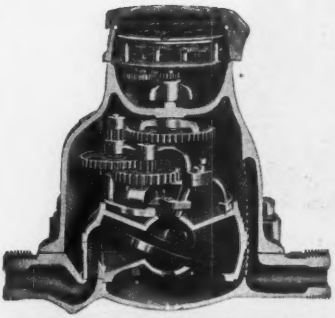

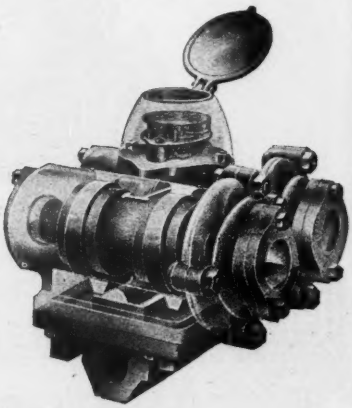

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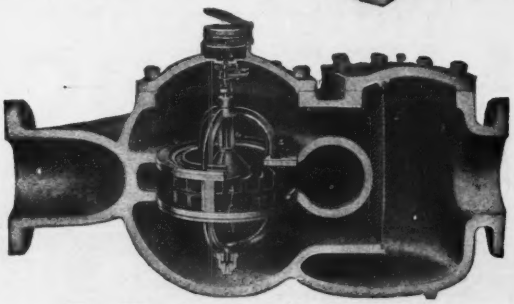

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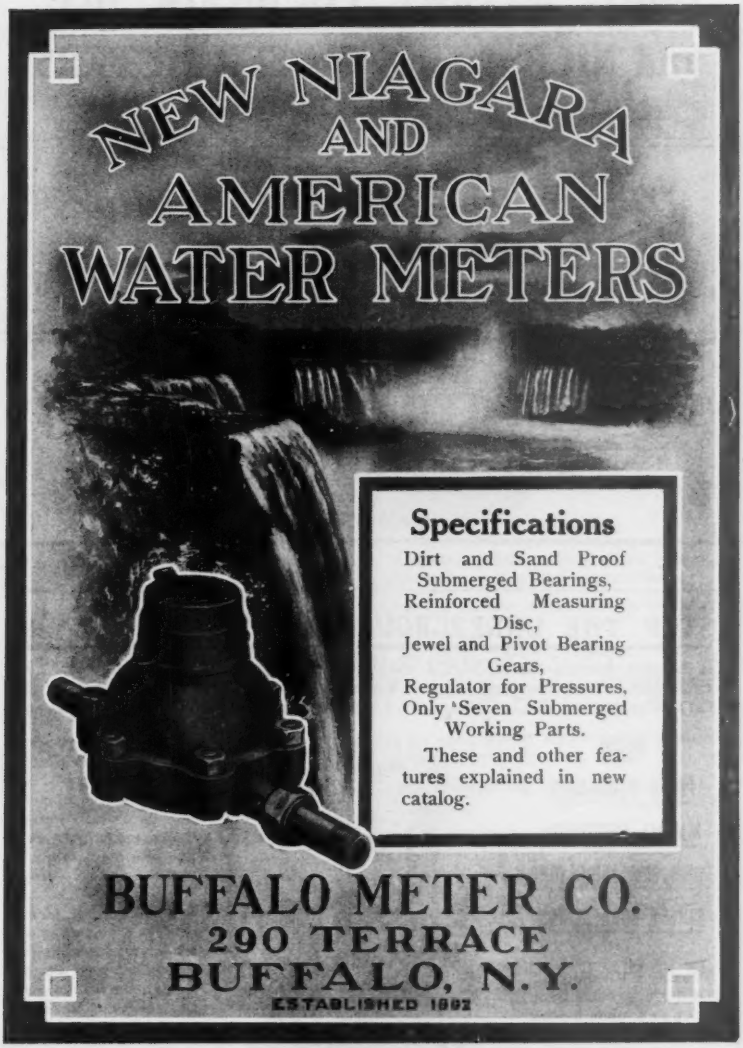

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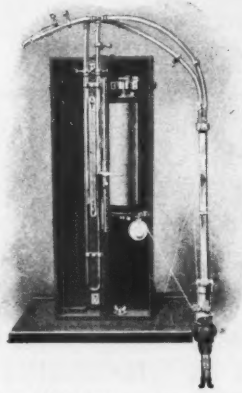

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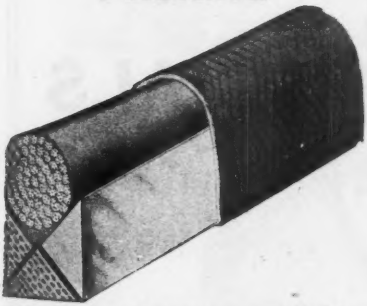

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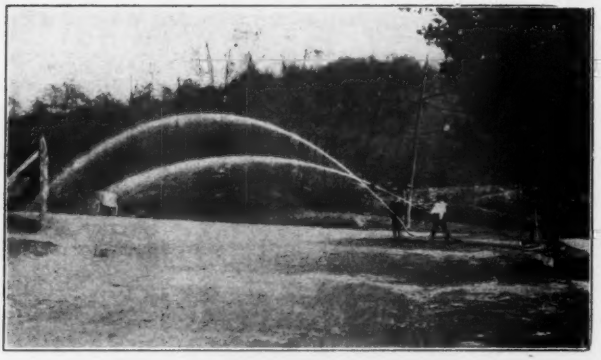

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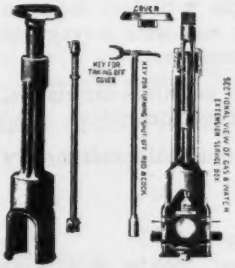

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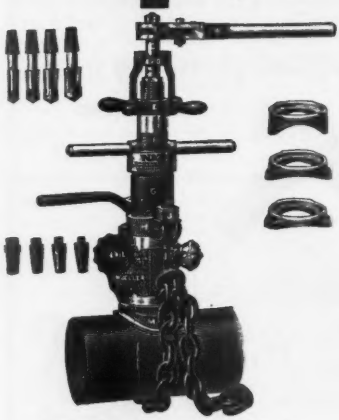

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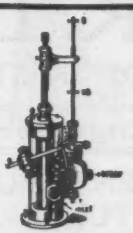

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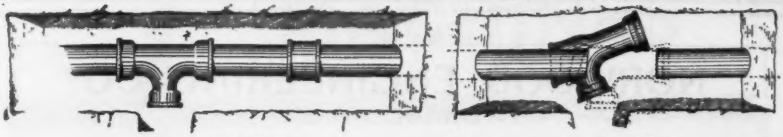

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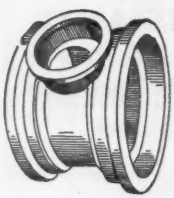

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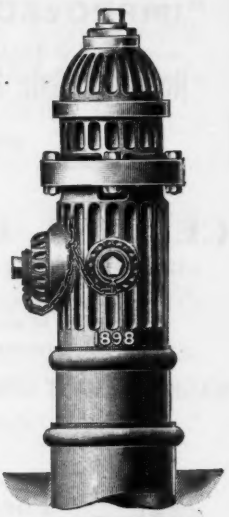

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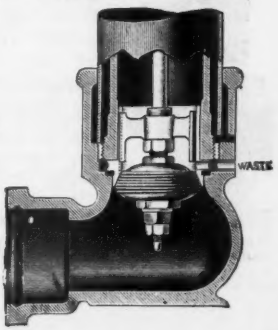

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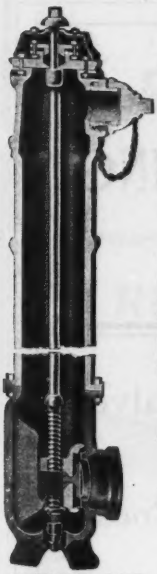

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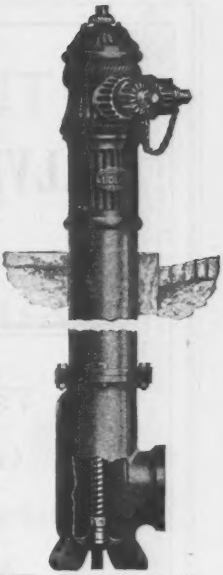

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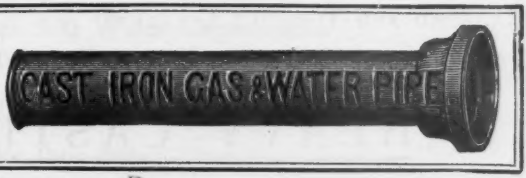

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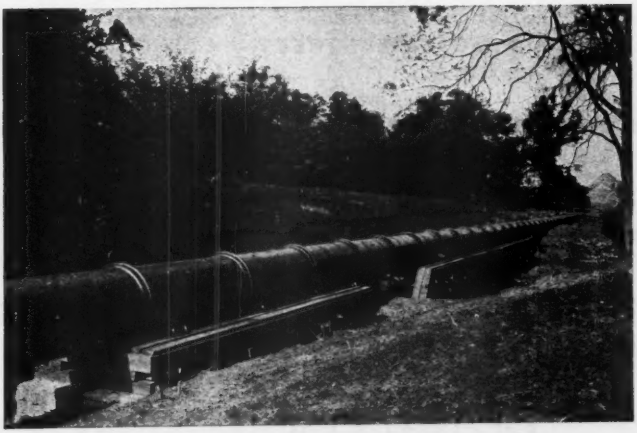

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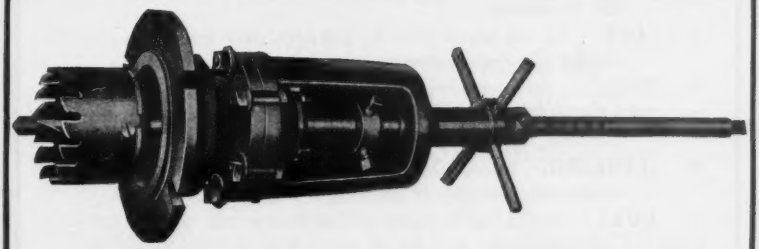

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